APPENDIX B

INTACT SHIP INFORMATION

B-1 INTRODUCTION

To be effective, the salvage engineer needs a general knowledge of ship form and construction, supplemented by information specific to a particular casualty. The characteristics of ships can be grouped by broad classes, because similar service requirements lead to similar forms. This appendix describes the sources of vessel-specific data available to the salvage engineer, including a short description of the NAVSEA drawing numbering system. Summary tables of pertinent characteristics of Navy ships are also included.

B-2 SHIP-SPECIFIC DATA

A great deal of information is generated and recorded during a ship's design, construction, and trials. Access to tabulated ship data can greatly simplify and speed the salvage engineer's work. The documents described in this paragraph are particularly useful.

Naval ships generally carry a greater body of ship's data than commercial ships. Documents carried onboard are normally kept in the engineering log room or technical library on naval ships. Documents for naval ships are also available from the parent squadron and repair activities; each ship class is assigned to a planning shipyard that maintains complete drawing files for assigned ships. Paragraph B-4 describes the NAVSEA ship's document numbering and classification system, gives planning yard assignments for Navy ships and craft, and describes likely sources for ship's documents.

Commercial vessels usually carry fewer documents than naval vessels, but the information contained in them is often quite detailed, especially in regard to hydrostatic characteristics and cargo capacity and stowage. Documents for commercial vessels are obtained from the ship's officers, owners or shipping company, agents, port engineer, building shipyard, or ship designer. Drawings for U.S. flag vessels can also be obtained from Chief, Naval Architecture Branch, Marine Technical and Hazardous Materials Branch, Headquarters, USCG, Washington D.C, 20593.

Most *current* drawings are accurate and reliable. Drawings and other documents describing ship's characteristics are revised to reflect changes to ship and component characteristics and to correct errors. Documents for Navy ships are normally revised during overhaul or major maintenance availabilities to reflect changes made during the overhaul/availability and previous changes or discrepancies reported by the ship's force or other organizations. Salvage personnel should verify that they are using the latest revision, as listed in the Ship's Drawing Index (SDI), and should be aware that the issuance of revised drawings may lag completion of the alteration by many months. Ships that have been inactive for many years are often objects of salvage or wreck removal; drawings may not reflect alterations made after the ship entered inactive status. When drawings and other data for a specific ship are not available, documents for similar ships are used. In such cases, the data should be used only as an indication of probable conditions, to be verified as the work progresses. Even drawings for ships of the same class may not be entirely accurate, especially in the particulars of component structures and systems. Design modifications are often made before a shipbuilding program is completed; only the later ships will be built with the modifications. Subsequent alterations may not be accomplished on all ships of the class; modifications cannot be made simultaneously to all ships. Shipyards are allowed some latitude in determining final details—ships built at different yards will usually have differences. The following are some typical differences between ships of the same class built at different yards:

- Tanks or compartment lengths, which may vary by a foot or more with attendant differences in tank capacities.
- The exact routing of piping and wiring systems.
- Arrangement and location of machinery room auxiliaries.
- Relative position and arrangement of staterooms, passageways, and other minor compartments not bounded by major structural or watertight bulkheads.
- Precise location of doors, hatches, fireplugs, and similar fittings.

The relative importance of the differences between documented and actual characteristics depends on the nature of the salvage operation and data required. Discrepancies should be noted and compiled to give a subjective evaluation of the data's reliability. For ships that will be returned to active service, discrepancies in published data should be included in the final salvage report and/or forwarded to the cognizant authority.

B-2.1 Curves of Form. Curves showing hydrostatic characteristics of a ship's hull are prepared by the designers. These curves are normally presented in a single document called the Curves of Form, Displacement and Other (D & O) Curves, or Hydrostatics Curves. This set of curves is often the single most useful document to a salvage engineer. Curves of Form are carried aboard Navy ships, usually in the custody of the Engineer or Damage Control Assistant. Figure FO-2 is an exact copy of the Curves of Form prepared by the designers for the frigate FFG-7 and other ships of the same class. On newer ships, the Curves of Form are presented on a single drawing with the Cross Curves of Stability and the Bonjean's Curves. The following information is available from the Curves of Form for Navy ships:

- Displacement in Saltwater (Δ_{SW}),
- Vertical Position of the Center of Buoyancy (*VCB* or *KB*),
- Longitudinal Position of the Center of Buoyancy (*LCB*),
- Longitudinal Position of the Center of Flotation (*LCF*),
- Tons per Inch Immersion (*TPI*),
- Height of the Transverse Metacenter above the Keel (*KM*), and
- Approximate Moment to Change Trim One Inch (*MT1*).

The Curves of Form drawing for older ships usually include the following additional curves:

- Displacement in Fresh Water (Δ_{FW}),
- Areas of Waterplanes (A_{WP}),
- Area of the Midship Section (A_M),
- Outline of the Midship Section,
- Longitudinal Metacentric Radius (BM_L),
- Area of Wetted Surface (*S*), and
- Curve of Sectional Areas.

All curves are entered from the ordinate scale with the value for mean draft. The value of the desired characteristic is read from the appropriate horizontal scale, or a factor is applied to the displacement value, as noted on the graph.

All characteristics are plotted as a function of mean draft, assuming zero trim. A ship trims about its center of flotation without changing displacement. If the center of flotation is not coincident with the midlength, mean draft differs from draft at the center of flotation; the displacement corresponding to the draft at the center of flotation is the true displacement, while taking displacement based on the mean draft returns an erroneous value. Because of this disparity, entering the curves with a known displacement will give an accurate mean draft only for a ship with no trim.

An additional curve is sometimes included to provide a correction to be applied to the value for displacement when the ship is trimmed. If there is no curve, displacement when trimmed is determined by entering the curve with the draft at the center of flotation. From Figure B-1, the difference between the mean draft and the draft at the center of flotation can be seen to be:

$$TC = \frac{dt}{L}$$

where:

TC	=	correction to mean draft for trim, in.
d	=	distance from midships to the center of flotation, ft
t	=	trim, in.
L	=	length between draft marks, ft

The correction is added to or subtracted from the mean draft, as appropriate. Alternatively, the draft correction can be multiplied by *TPI* to calculate a displacement correction to be applied to the displacement returned by the mean draft. For the situation shown in Figure B-1, *LCF* is abaft midships and there is trim by the bow, so the correction is negative. It is helpful to draw a similar sketch for each situation to determine whether the correction is added or subtracted.

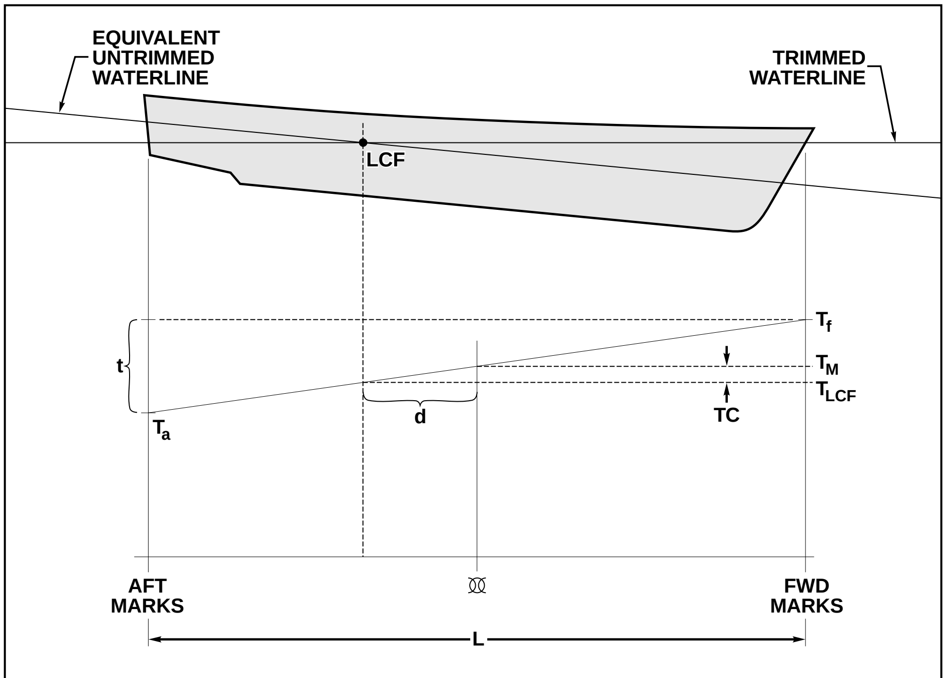


Figure B-1. Correction to Displacement for Trim.

For Navy ships, the above correction need not be made if a draft diagram is available. See Paragraph B-2.6.2 for instructions on the use of draft diagrams.

If a ship has appreciable hog, the draft at midships is less than the mean draft. Since ships are fuller in the midbody than at the ends, the displacement is less than that indicated by the mean draft. Similarly, if the ship is sagging, the draft amidships is greater than the mean draft and displacement is greater than that indicated by mean draft. When displacement is calculated by integration of sectional areas, Bonjean's Curves can be entered with the actual forward, after, and amidships drafts. Sectional areas at intermediate stations are obtained from the curves by assuming the hull deflection follows a parabolic form, either by sketching a deflected waterline on a profile arrangement of the Bonjean's Curves, or by interpolating drafts for the intermediate stations. When a displacement curve is used, a common practice is to enter the displacement curve with a corrected midships draft equal to the mean of the forward and after drafts, plus or minus a fraction of the deflection at midships. The deflection is added for sag or decreased for hog—i.e., the correction brings the calculated midships draft towards the observed midships draft. For a rectangular waterplane, the correction is two-thirds the deflection, since the area under a parabola is two-thirds that of a circumscribing rectangle. For most commercial hull forms, 0.75 times deflection is a reasonable approximation.

B-2.2 Offsets. Offsets are tabulated as described in Paragraph 1-2.7. They are often included in a set of drawings with the lines plans (e.g., *Molded Lines and Offsets for OLIVER HAZARD PERRY*). Waterline halfbreadths and deck heights/halfbreadths are tabulated for 21 stations on the FFG-7 Lines Plan (FO-1). Detailed offsets with very close station spacing are also prepared and are useful for computing volumes of compartments or groups of compartments. Similar detailed tank offsets may also be available.

B-2.3 Bonjean's Curves. Bonjean's Curves or Curves of Sectional Areas are a collection of curves plotting sectional area along the *X*-axis against draft on the *Y*-axis. The curves are usually presented in one of the two formats shown in Figure FO-3. The section area curve may show area for either the whole section, or for one side only, as noted on the drawing. The areas generally do not account for appendages, but may include shell plating, as noted on the drawing. The curve of the midships section area from the curves of form is essentially the Bonjean's Curve for the midships section.

The *rosette* arrangement (FO-3A), with all the curves drawn to a single set of axes, produces a more compact drawing and is favored by some designers because lack of fairness in the hull will show itself with the curves lying side by side. When calculating buoyancies for varying waterlines or wave profiles, it is sometimes more convenient to arrange the curves along the ships profile, with a vertical axis at each station, as shown in FO-3B, so the section areas can be picked off at each station. If the Bonjean's Curves are not available in this format, the curves and area scale can be traced from the rosette onto a hull profile drawn on tracing paper. The horizontal length scale for the hull profile is not critical, but should be consistent throughout its length if buoyancy is to be calculated on waterlines that are not horizontal.

B-2.4 Inclining Experiment. The most important piece of information generated by an inclining experiment is the location of the center of gravity for a given condition of loading. This information is provided in a *Booklet of Inclining Experiment Data* or *Report of Inclining Experiment,* along with other information such as:

- Complete stability information for certain conditions of loading, including maximum and minimum operating conditions.
- A detailed statement indicating weight and location of boats, aircraft, ordnance equipment, and permanent ballast.
- A summary of the consumable loads such as fuel, water, ammunition and stores included in each condition, including displacement, *KG*, *GM*, and drafts for each loading.
- A table of approximate changes in metacentric height due to added weights in specific tanks or compartments.
- Displacement and other curves.
- Curves of statical stability for specified operating conditions.

Part 1 of the report or booklet contains observations and calculations leading to the determination of displacement and location of center of gravity for the light ship condition. Part 2 contains stability information for operating conditions and is titled *Stability Data* for surface ships and *Stability and Equilibrium Data* for submarines.

It is customary to perform an inclining experiment on only one or two ships of any class, applying the information obtained to all ships of the class. Inclining experiments may be performed several times in a ship's life, to account for major alterations. In using inclining experiment data, it is important to ascertain the effect of any changes made since the experiment.

B-2.5 Stability and Loading Data Booklet. Information formerly included in the Inclining Experiment Booklet is now provided to Navy ships in the Stability and Loading Data Booklet in addition to:

- Limiting drafts,
- Table of tank capacities, and
- Cross curves of stability.

B-2.6 Damage Control (DC) Book. Damage control books issued to Navy ships contain text, tables and diagrams providing information concerning the ship's damage control characteristics and systems. These books normally include the information described in the following paragraphs, and may reproduce information from tank sounding tables, stability and loading data booklets, cross curves of stability and other sources. Part II(A) of the DC Book gives stability and loading information. Copies of the damage control book are kept in damage control central, each repair locker, and on the bridge. Excerpts from an FFG-7 DC Book are included in Appendix H.

B-2.6.1 Tables and Drawings. The Damage Control Book includes tables and drawings showing the locations of:

- Watertight and fumetight doors, hatches and scuttles.
- Ventilation fittings, fans and controllers.
- Fire main piping valves and stations.
- Drainage system piping and valves.
- Sound-powered phone circuits and jacks.

B-2.6.2 Draft Diagram and Functions of Form. The draft diagram in the Damage Control Book is a nomograph for determining the displacement from observed drafts. There are several forms of draft diagrams. In the simplest form, drafts are plotted on vertical scales at the forward and after draft marks, and displacement is plotted along a line describing the position of the center of flotation relative to the draft marks at any draft. Additional scales can be added to show other hydrostatic functions, as shown in Figure H-1, a copy of the draft diagram for an FFG-7 Class ship. Displacement in saltwater is read from the intersection of the displacement scale with a straight line connecting forward and after drafts. Other parameters are shown by the intersection of the appropriate scale with a horizontal line passing through the displacement (the intersection of this line with the draft scales shows the draft at *LCF*). A second form is similar, except that drafts are plotted on the center of flotation scale and a table gives displacements for *LCF* drafts. A third form reads displacement from a vertical scale at midships and gives a correction for trim on the diagram. Draft diagrams are generally less accurate than the displacement curve, are developed for saltwater only, and are not accurate when the ship has excessive trim.

B-2.6.3 Damage Control Plates. The damage control plates provided with the damage control book are a series of plan and orthographic drawings of the ship at various levels showing:

- Watertight, oiltight, fumetight and airtight subdivision of the ship and all fire zones.
- Routing of firemain and drainage piping systems.
- Location of all watertight and fumetight doors, hatches and scuttles.
- Routing of ventilation systems.

Damage control plates are drawn to scale but it is often difficult to pick dimensions off of orthographic views. The damage control plates include flooding effect and liquid load diagrams. The liquid load diagram is Plate No 1.

B-2.6.4 Liquid Load Diagram. The liquid load diagram is a set of plan views of the ship showing all tanks and spaces fitted for carrying liquids. Figure B-2 shows the format in which the following information is presented for each tank.

- Tank location and boundaries.
- Compartment number (center).
- Tons of seawater to completely flood the compartment, allowing for permeability (upper left hand corner).
- List caused by completely flooding the compartment (upper right hand corner).
- Changes in draft forward and aft caused by completely flooding the compartment (lower corners).

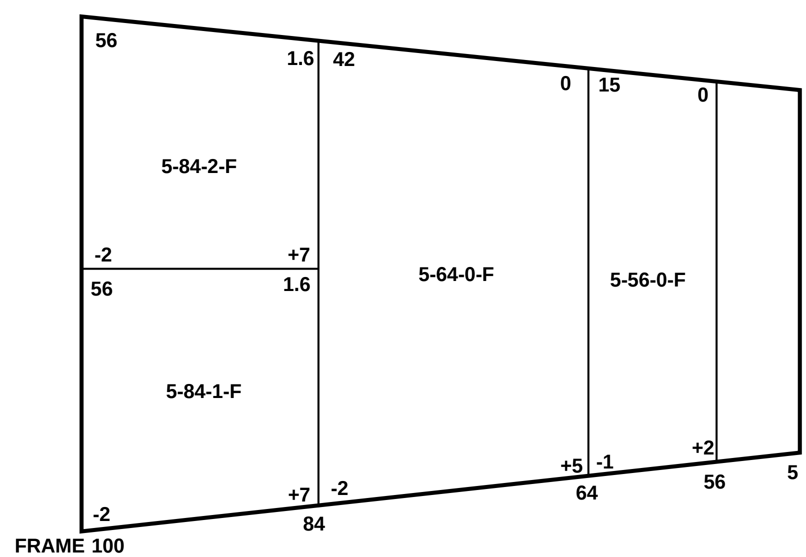


Figure B-2. Liquid Load Diagram.

- Additional information as noted on the plate legend.

Each tank is colored to indicate its use in accordance with the color code given on the diagram. The data given for list and trim is based on a specified condition of loading and is not applicable when the ship is unusually loaded or severely damaged.

B-2.6.5 Flooding Effect Diagram. The flooding effect diagram is a series of plan views showing all watertight, oiltight, airtight, fumetight and fire retarding subdivision. Figure B-3 shows the format of the diagram. The following information is given for each compartment:

- Compartment number (center).
- Tons of saltwater to flood the compartment (upper left-hand corner).
- Transverse moment in foot-tons for all unsymmetrical and offcenter compartments (lower right-hand corner).
- Additional information as noted on the plate legend.

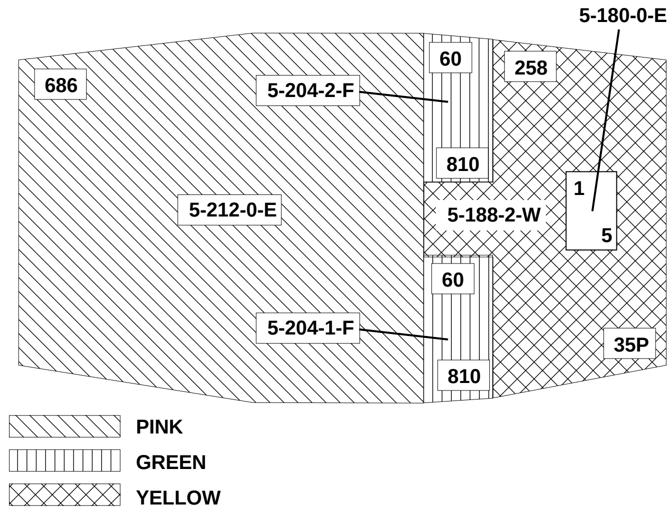


Figure B-3. Flooding Effect Diagram.

- Relative effect on stability is indicated by color code:

Pink	Flooding impairs stability due to added high weight, free surface effect or both.
Green	Flooding improves stability even if free surface exists.
Yellow	Solid flooding improves stability, but flooding with free surface impairs stability.
No color	Flooding has no appreciable affect on stability.

Flooding effect diagrams provide a ready reference for the location of watertight boundaries in the intact ship and transverse moments due to flooding assuming the boundaries shown remain intact.

B-2.7 Tank Sounding Tables or Curves. Tank sounding tables or curves are developed for use by the ship's fuel and water king. These curves or tables correlate tank soundings (levels) to volume in gallons. Curves for newer Navy ships give the center of gravity of the liquid and moment of inertia of the free surface for any sounding. Sounding tables are generally available onboard, although the sounding curves may not be.

B-2.8 Compartment Areas and Volumes. Tables showing the plan area and volumes of watertight compartments are prepared for U.S. Navy ships as part of their drawing set. These tables may be included in the damage control book or maintained separately.

B-2.9 Booklet of General Plans. The Booklet of General Plans prepared for U.S. Navy ships is a complete set of arrangement plans for the ship. Plan views of each deck, inboard and outboard profiles, and a number of transverse sections are usually included. Tables of principal dimensions and heights of various decks and objects are often included. Limited scantlings are sometimes included. Dimensions may be scaled from these plans.

B-2.10 Ship's Information Book. U.S. Navy ships are provided a multi-volume Ship's Information Book (SIB) that describes the ship and its systems. Although some of this information is duplicated in the Damage Control Book, the ships information book will also address systems and components not related to damage control. Volume 1 usually contains information of a general nature, and may be titled the *General Information Book*.

B-2.11 Structural Plans. Structural plans, sometimes called *scantlings plans,* show dimensions of the ships framing and plating. The midships section drawing, generally available for all ships, and the shell expansion plan are particularly useful. The midships section drawing provides the data required for the midships section modulus calculation. The shell expansion plan and larger scale shell plating drawings show details of the hull plating such as the size, thickness, and material of the plating. They also show details of openings, fittings, and appendages attached to the plating. Much of the data needed for designing patches and structural repairs, and for determining the feasibility of making hull cuts can be obtained from shell drawings. For Navy ships, a longitudinal strength plan, similar to that shown in Figure FO-4, is prepared. The plan shows weight distribution for a specified loading condition (usually full load), shear and bending moment curves for the ship hogged and sagged on the standard trochoidal wave, structural drawings for several stations (usually from station 3 to station 17), and tabulated moments of inertia and heights of the neutral axis for most of the middle stations. Standard scales for Navy drawings are:

Length	1 in.	=	L/20 ft
Weight/Buoyancy Ordinates	1 in.	=	W/3L ton/ft
Weight/Buoyancy Area	1 in^2	=	W/60 tons
Shear Ordinates	1 in.	=	W/30 tons
Shear Area	1 in^2	=	WL/600 ft-tons
Moment Ordinates	1 in.	=	WL/200 ft-tons

The derivation of the standard scales is described in Paragraph 1-12.8.

B-2.12 Docking Plans and Reports. In addition to docking information, the ship docking plan shows the underwater profile of the ship, the plan view of its bottom, and locations of underwater appendages, sea suctions, and overboard discharges, with reference points and measurements to locate them. The docking plan also provides vertical measurements from the main deck and base line, the location and dimensions of the docking blocks for the three docking positions, and the critical dimensions of the ship.

Docking reports provide a complete and accurate description of the ship's bottom. They describe the results of inspections and work done while the ship is in dry dock. Reports for emergent or unplanned dockings do not provide a complete bottom description, but address only the work done during the docking; reports of unplanned drydockings can be considered supplements to the report of the previous regular dry docking. Docking reports are further supplemented by subsequent underwater hull inspection, hull cleaning, and repair or work reports. In addition to an overall description of the ship's bottom, docking reports include two items of interest to salvors: the shaft covering, if any, and the type of paint applied to the ship's bottom and appendages. Information on paint systems and coverings alerts the diving supervisor to potential toxic hazards.

B-2.13 Trim and Stability Booklet. Commercial ships usually have a trim and stability booklet which may contain either curves of form or hydrostatic tables and stability and trim characteristics for various conditions of loading. U.S. registered inspected vessels and uninspected vessels over 79 feet in length are required to carry trim and stability booklets or equivalent data. Uninspected vessels under 79 feet may not have trim and stability booklets.

A typical trim and stability booklet will contain the following data:

- Vessel characteristics, including principal dimensions, tonnage, location of draft marks, builder, official and registry numbers, etc.
- Instructions for use of the nomograms, curves, and other data in the booklet to calculate stability and trim of the vessel for given loading conditions.
- General operating instructions and precautions.
- Tabulated tank and hold capacities.
- Hydrostatic properties (*KM*, *LCB*, *LCF*, etc.) tabulated or plotted as a function of mean draft. Figure B-4 shows a typical hydrostatic table.

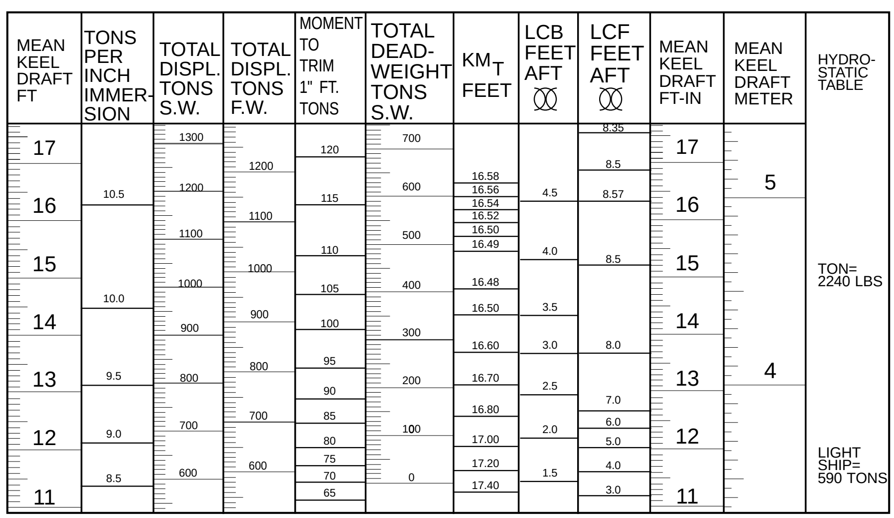
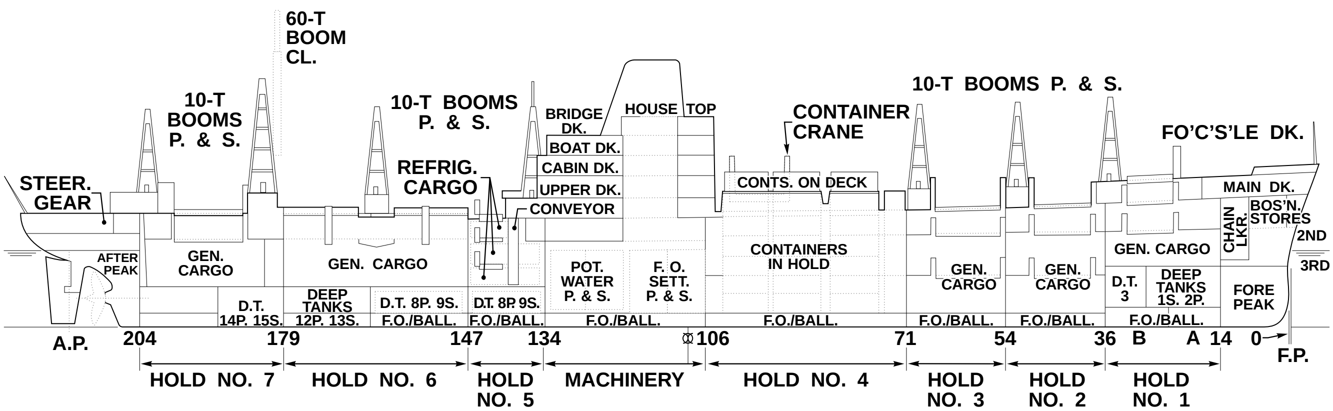


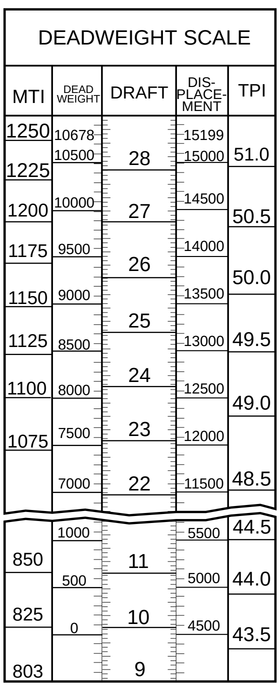
Figure B-4. Typical Hydrostatics Table.

- Metacentric Height (*GM*) diagram, showing *GM* for tabulated conditions of loading and minimum required *GM* for vessel service.
- Trim diagram to calculate vessel trim when weights are added at locations other than the vessel center of gravity.
- Weight distribution and stability information for various conditions of loading.
- Liquid loading diagram, showing the location, capacity, and effect on list and trim of the ship's tanks.

B-2.14 Deadweight Scale. Merchant (cargo carrying) ships often use an abbreviated hydrostatic table, or deadweight scale, that shows deadweight capacities and Tons per Inch Immersion corresponding to various drafts from below lightweight to displacement fully loaded.

B-2.15 Capacity Plan. A merchant ships capacity plan will show the cubic capacities of tanks and cargo carrying spaces such as holds, 'tween deck and shelter decks. Tank capacity in tons of fuel, saltwater or other liquids may be included. Deadweight scales and trim diagrams are often included. Figure B-5 illustrates a typical capacity plan for a general cargo ship.





PRINCIPAL PARTICULARS

LENGTH OVERALL	171.8m (563'-7 3/4")
LENGTH BETW, PERPS. (ABS)	161.1m (528'-6")
BREADTH, MOLDED	23.2m (76'-6")
DEPTH, MLD., MAIN DK AT SIDE	13.6m (44'-6")
DRAFT, KEEL, AT ASSIGNED FBD	9.6m (31'-7 1/8")
GROSS TONNAGE, U.S.	13223
NET TONNAGE, U.S.	8008
GROSS TONNAGE, PANAMA	13653
NET TONNAGE, PANAMA	9966

TYPICAL SUMMARY TABLES

DRY CARGO

HOLD	DECK	FRS.	GRAIN m^3	BALE m^3	VCG m	LCG m
1	MN.	17-37	425	395	17.3	62.0 F
2	2' ND	36-54	807	741	13.3	48.6 F
TOTAL, 7 HOLDS			16315	15062	9.6	2.3A

CONTAINERS

HOLD	DECK	FRS.	TIERS	NO.	CAP m^3	VCG m	LCG m
4	MN.	76-103	1	18	570	17.4	14.9 F
4	TK.TOP	76-103	6	108	3419	8.8	14.9 F
TOTAL				126	3989	10.1	14.9 F

REFRIGERATED CARGO

HOLD	DECK	FRS.	NET CAP m^3	VCG m	LCG m
5	2' ND	137-147	196	12.3	25.1 A
5	26.5' FLT.	134-147	267	9.4	23.6 A
TOTAL			732	9.1	24.0 A

PERMISSIBLE DECK LOADING TYPICAL

DECK	FRAMES	TONNES/M^2
TANK TOP	14-36	3.72
TANK TOP	75-106	7.00
MAIN DK.	14-208	2.50

CARGO OIL

COMPT.	FRS.	TONNES	VCG m	LCG m
D.T. #1, S	14-28	94.3	5.0	65.3 F
D.T. #1, P	14.28	94.0	5.1	65.3 F
TOTAL		1489.0	3.7	3.3 F

FUEL OIL AND BALLAST

COMPT.	FRS.	FUEL TONNES	BALLAST TONNES	VCG m	LCG m
FOREPEAK	0-14		112.5	3.6	61.8 F
1A DB	14-24	49.4	53.7	1.4	67.1 F
TOTAL		4863.0	5072.0	2.5	4.3 A

NOTE: L.C.G. FOR'D (F) AND AFT (A) MEASURED FROM AMIDSHIPS, 81.7 m (268 FT) FOR'D OF A.P.

Figure B-5. Capacity Plan - Multi-Purpose Dry Cargo Ship.

B-2.16 Component Drawings. Individual component drawings are valuable planning tools and can provide dimensions required to evaluate strength of attachment points, determine clearances to prevent damage to screws, rudders, or other appendages, or to build enclosing cofferdams or patches.

B-2.17 Logs and Records. Logs and operating records can help the salvor determine the ship's condition shortly before the incident. For example, records showing consumption of fuel and other provisions are helpful in determining actual displacement immediately before stranding.

B-2.18 Computer-generated Information. There are a number of naval architecture programs in use today. The application of computer programs and data bases to ship salvage is addressed in Volume 2 of this handbook, but the Ship Hull Characteristics Program (SHCP), the International Graphics Exchange System (IGES), and the *Program of Ship Salvage Engineering (POSSE)* bear brief mention here.

The FORTRAN-based SHCP is used by Naval Sea Systems Command designers to analyze intact and damaged stability of hull forms defined by input data (offsets). The program can develop hydrostatic functions and stability data for the hull in various conditions of trim and loading. The data can be output in either tabular or graphical format. SHCP was developed to run on mainframe computers, but a modified version runs on certain microcomputers. For ships designed after SHCP became operational (ca. 1977), SHCP data files are maintained by NAVSEA Code 55W. Electronic data files or output hydrostatic and stability files can be provided. SHCP data files may also exist for ships designed before 1977, if extensive weight and moment studies have been conducted since SHCP was placed on line. The U.S. Coast Guard Marine Safety Center, Washington D.C., maintains SHCP data files for over 2,500 commercial hulls. The data files are cataloged by vessel name and builders hull number—not by official or registry number. Hydrostatic tables or electronic data files can be provided.

IGES data files are maintained for newer Navy ships at planning shipyards. The IGES files can be read by computer assisted design (CAD) programs to develop ship drawings.

The NAVSEA *POSSE* program takes hull offsets as its basic inputs to perform salvage calculations. Providing lightship weight distribution and tank definition by offsets enables the program to rapidly calculate the effects of liquid transfers on stability and hull strength, with minimum keyboard input. NAVSEA is pursuing a program of extracting hull and tank offsets, appendage volumes, and lightship weight distribution to be provided to *POSSE* users in floppy disk format. The program can use SHCP files and has a rapid analysis mode based on the parametric hull characteristic determination method described in Paragraph 1-7.

B-2.19 Shipping Registers. Shipping registers, compiled by classification societies, commercial firms, and regulatory agencies, provide limited but useful ship characteristics. The data from shipping registers can be used with the parametric calculation method described in Paragraph 1-7, or with the NAVSEA *POSSE* program. Figure B-6 shows an excerpt from *Lloyds Register of Ships*, illustrating the extent of data typically available.

1	2	3	4	5	6	7
LR NUMBER	SHIP'S NAME	TONNAGE	CLASSIFICATION	HULL	SHIP TYPE/CARGO FACILITIES	MACHINERY
Call Sign	Former Names	Gross	Hull Special Survey	Date of build Shipbuilders-Place of build	Propulsion Ship type Shelter Deck	No. & Type of Engines Bore × stroke (mm)
		Net		Yard Number	Passengers	
Official No.	Owners	Deadwt		Length overall (mm) Breadth extreme (m) Draught maximum (m)		Power Design
			Machinery	Length B.P.(m) Breadth Molded (m) Depth Molded (m)	Holds & lengths (m)/Cargo tanks & types	Enginebuilders Where manufactured
Navigational Aids	Managers	*Gross		Superstructures (m) Decks	Grain/Liquid (m^3) Bale (m^3) Insulated spaces (m^3) Heating coils	Boilers Pressures Heating surface Furnaces
	Port of Registry	*Net	Refrigerated Cargo Installation	Riveted/ Welded Rise of floor (mm) Keel	Containers and lengths (ft)	Aux. electrical generating plant & output
	Flag	Deadwt	Equipment Letter	Alterations	Hatchways & sizes (m)	Special propellers
				Bulkheads Water ballast Conversions	Winches Cranes/Derricks (SWL tonnes)	Fuel bunkers (tonnes) Speed
		(tonnes)	Fee Numeral			

* Two gross and two net tonnages may be recorded for ships designed to carry either ore or oil cargoes

Figure B-6. Lloyd's Register of Ship's Entry.

B-3 STANDARD VESSEL DESIGNATIONS

Ships are grouped into similar types, often designated by letters and/or numbers. There are four standard vessel designation systems in use in the United States:

- U.S. Navy.
- U.S. Coast Guard.
- U.S. Army.
- Maritime Administration (MARAD).

B-3.1 U.S. Navy Ship and Service Craft Designators. U.S. Navy ships and service craft fall into two major categories: combatant and auxiliary/support. Vessel type is indicated by a 2- to 4-letter designator from Table B-1. Ships and large craft are assigned hull numbers that follow the type designator. A letter "T" (T-ATF, T-AO, etc.) before the identifying classification and hull number of a naval vessel indicates that the vessel is assigned to the Military Sealift Command (MSC). A letter "N" after the identifying classification indicates that the vessel is nuclear-powered. The names of commissioned ships are preceded by the letters USS (United States Ship), those of MSC operated vessels by USNS (United States Naval Ship). Boats are assigned individual serial numbers, and may be assigned identifying numbers by operating activities. Boats assigned to ships, including landing craft (LCM) are identified by the parent ship's hull type and number followed by unique, sequential number (LKA-116-4, ARS-52-2, etc.).

Table B-1. U.S. Navy Ship and Craft Designations.

Combatant Ships		Auxiliary Ships	
AGF	miscellaneous command ship (converted LPD)	ACS	auxiliary crane ship
BB	battleship	AD	destroyer tender
CA	gun cruiser*	AE	ammunition ship
CG	guided missile cruiser	AF	store ship
CV	multipurpose aircraft carrier	AFS	combat store ship
CVS	ASW aircraft carrier*	AG	miscellaneous
DD	destroyer	AGDR	deep-submergence support ship
DDG	guided missile destroyer	AGEH	hydrofoil support ship
DE	destroyer escort* (active DE redesignated FF)	AGFF	frigate research ship
DEG	guided missile destroyer escort* (active DEG redesignated FFG)	AGM	missile range instrumentation ship
DL	destroyer leader*	AGOR	oceanographic research ship
DLG	guided missile destroyer leader* (active DLG redesignated CG/DDG)	AGOS	ocean surveillance ship
FF	frigate	AGP	patrol craft tender
FFG	guided missile frigate	AGS	surveying ship
LHA	amphibious assault ship (general-purpose)	AGSS	auxiliary research submarine
LHD	amphibious assault ship (multipurpose)	AH	hospital ship
LPH	amphibious assault ship (helicopter)	AK	cargo ship
LPD	amphibious transport dock	AKB	cargo ship, barge carrying
LKA	amphibious cargo ship	AKR	cargo ship, vehicle
LPA	amphibious transport*	AKX	prepositioning ship
LSD	dock landing ship	ALS	auxiliary lighter ship
LSM	medium landing ship*	AN	net tender*
LSMR	barrage rocket ship* (converted LSM)	AO	oiler
LST	tank landing ship	AOE	fast combat support ship
LCC	amphibious command ship	AOG	gasoline tanker
MSC	minesweeper (coastal)	AOR	replenishment oiler
MSO	minesweeper (ocean)	AOT	transport oiler
MCM	mine countermeasures ship	AP	transport
PC	patrol combatant* (similar to corvette)	APB	self-propelled barracks ship
PCS	patrol combatant, minesweeping*	AR	repair ship
PF	patrol frigate*	ARC	cable-repairing ship
PG	patrol gunboat*	ARL	repair ship (small)
PGH	patrol gunboat (hydrofoil)	ARS	salvage ship
PHM	patrol combatant, missile (hydrofoil)	AS	submarine tender
SC	submarine chaser*	ASR	submarine rescue ship
SS	attack submarine	ATF	ocean tug
SSG	guided missile submarine*	ATS	salvage tug
SSN	attack submarine (nuclear)	AVB	aviation logistics support ship
SSBN	ballistic missile submarine (nuclear)	AVM	guided missile research ship
SSAG	auxiliary submarine*	AVT	auxiliary aircraft landing training ship

* Vessel type not currently active

Table B-1 (Continued). **U.S. Navy Ship and Craft Designations.**

Combatant Craft		Yard and Service Craft			
AALC	amphibious assault landing craft	AFDB	large auxiliary floating dry dock, (SP)	YG	garbage lighter (SP)
ATC	mini-armored troop carrier	AFDL	small auxiliary floating dry dock (NSP)	YGN	garbage lighter (NSP)
COOP	craft of opportunity (minesweeping)	AFDM	medium auxiliary floating dry dock (NSP)	YHLC	salvage lift craft, heavy* (NSP)
CPIC	coastal patrol and interdiction craft	ARD	auxiliary repair dry dock (NSP)	YMLC	salvage lift craft, medium*
LCAC	landing craft, air-cushion	ARDM	medium auxiliary repair dry dock (NSP)	YLLC	salvage lift craft, light*
LCM	landing craft, mechanized	APL	barracks craft (NSP)	YM	dredge (SP)
LCPL	landing craft, personnel, large	DSRV	deep-submergence rescue vehicle	YN	net tender* (SP)
LCT	landing craft, tank*	DSV	deep-submergence vehicle	YNG	gate craft (NSP)
LCU	landing craft, utility	IX	unclassified miscellaneous	YO	fuel oil barge (SP)
LCVP	landing craft, vehicle, personnel	NR	submersible research vehicle	YOG	gasoline barge (SP)
LSSC	light seal support craft	YAG	miscellaneous auxiliary (SP)	YOGn	gasoline barge (NSP)
LWT	amphibious warping tug	YBD	bowdock	YON	fuel oil barge (NSP)
MSB	minesweeping boat	YC	open lighter (NSP)	YOS	oil storage barge (NSP)
MSD	minesweeping drone	YCF	car float (NSP)	YP	patrol craft (SP)
MSH	minehunter	YCV	aircraft transportation lighter (NSP)	YPD	floating pile driver (NSP)
MSI	minesweeper, inshore	YD	floating crane (NSP)	YR	floating workshop (NSP)
MSL	minesweeping launch	YDT	diving tender (NSP)	YRB	repair and berthing barge (NSP)
MSM	minesweeper, river (converted LCM-6)	YF	yard freighter	YRBM	repair, berthing, and messing barge (NSP)
MSR	minesweeper, patrol	YFB	ferry (SP)	YRDM	floating dry dock workshop (machine) (NSP)
MSSC	medium seal support craft	YFD	yard floating dry dock (NSP)	YRR	radiological repair barge (NSP)
PB	patrol boat	YFN	covered lighter (NSP)	YRST	salvage craft tender (NSP)
PBR	river patrol boat	YFNB	large covered lighter (NSP)	YSD	seaplane wrecking derrick (SP)
PCF	patrol craft (fast)	YFND	dry dock companion boat (NSP)	YSR	sludge removal barge (NSP)
PT	patrol, torpedo boat*	YFNX	lighter, special-purpose (NSP)	YTB	large harbor tug
PTF	fast patrol craft	YFP	floating power barge (NSP)	YTL	small harbor tug
SDV	swimmer delivery vehicle	YFR	refrigerated covered lighter (SP)	YTM	medium harbor tug
SWCL	special warfare craft, light	YFRN	refrigerated covered lighter (NSP)	YW	water barge (SP)
SWCM	special warfare craft, medium	YFRT	covered lighter (range tender) (SP)	YWN	water barge (NSP)
SLWT	side-loading warping tug	YFU	harbor utility craft (SP)		

* Vessel type not currently active

SP Self-propelled
NSP Not self-propelled

B-3.2 U.S. Coast Guard Vessel Designations. All vessels of the U.S. Coast Guard are called cutters, the vessel name is preceded by USCGC. Craft less than 65 feet in length are assigned serial numbers; the first two digits of the serial number indicate the nominal length, in feet. Larger vessels are assigned hull numbers similar to naval ships, preceded by the applicable prefix from Table B-2.

Table B-2. U.S. Coast Guard Vessel Designations.

WHEC	High-endurance cutter (similar to frigate)	WLB	Seagoing buoy tender
WMEC	Medium-endurance cutter (similar to small frigate or corvette)	WLM	Coastal buoy tender
WAGB	Icebreaker	WLI	Inland buoy tender
WTGB	Icebreaking tug	WLR	River buoy tender
WSES	Surface effect craft	WLIC	Inland construction tender
WPB	Patrol craft, large	WYTM	Medium harbor tug
WIX	Training cutter (sail bark Eagle)	WYTL	Small harbor tug

B-3.3 U.S. Army Vessel Designations. Each vessel bears an individual serial number, preceded by the applicable prefix from Table B-3. The names of Army vessels are preceded by USAV (United States Army Vessel). Army craft are described and illustrated in the Army technical manual, *TM 55-500, Marine Equipment Characteristics and Data*.

Table B-3. U.S. Army Vessel Designations.

BC	barge, dry-cargo, nonpropelled, medium (100 through 149 feet)	FS	freight and supply vessel, large (140 feet and over)
BCDK	conversion kit, barge deck enclosure	HLS	heavy lift ship
BCL	barge, dry-cargo, nonpropelled, large (150 feet and over)	J	boat, utility
BD	crane, floating	LACV	lighter, air-cushion vehicle
BDL	lighter, beach discharge	LARC	lighter, amphibious, resupply, cargo
BG	barge, liquid-cargo, nonpropelled	LCM	landing craft, mechanized
BK	barge, dry-cargo, nonpropelled	LCU	landing craft, utility
BPL	barge, pier, nonpropelled	LT	tug, large, seagoing
BR	barge, refrigerated, nonpropelled	ST	tug, small, harbor
FB	ferry	T	boat, passenger and cargo
FD	dry dock, floating	TCDF	temporary crane discharge facility
FMS	repair shop, floating, marine craft, nonpropelled	Y	vessel, liquid cargo

B-3.4 Maritime Administration (MARAD) Classification System. The MARAD system classifies ships by design type. Three groups of letters and numbers indicate the characteristics of the ship:

Group 1 – An alpha-numeric group from Table B-4 indicating ship type and length on the load waterline (LWL).

Group 2 – One, two, or three letter group from Table B-5 indicating type of machinery, number of propellers, and passenger capacity.

Group 3 – Chronological design number and alteration letter (assigned by MARAD).

For example, *C4-S-1a* denotes a cargo vessel of between 500 and 550 feet with steam propulsion and one propeller, carrying less than 12 passengers. The ship is version *a* of the first design.

Table B-4. MARAD Classification System (Group 1).

		Length at Load Waterline (ft)							
Ship		(1)	(2)	(3)	(4)	(5)	(6)	(7)	Remarks
B	Barge	up to 100	100 to 150	150 to 200	200 to 250	250 to 300	300 to 350	350 to 400	(1)
C	Cargo	up to 400	400 to 450	450 to 500	500 to 550	550 to 600	600 to 650	650 to 700	(1)
G	Great Lakes cargo	up to 300	300 to 350	350 to 400	400 to 450	450 to 500	500 to 550	550 to 600	(1)
H	Great Lakes passenger	up to 300	300 to 350	350 to 400	400 to 450	450 to 500	500 to 550	550 to 600	(2)
IB	Integrated tug-barge	up to 200	200 to 300	300 to 400	400 to 500	500 to 600	600 to 700	700 to 800	(1)
J	Inland cargo	up to 50	50 to 100	100 to 150	150 to 200	200 to 250	250 to 300	300 to 350	(2)
K	Inland passenger	up to 50	50 to 100	100 to 150	150 to 200	200 to 250	250 to 300	300 to 350	(2)
L	Great Lakes tanker (ore or grain)	up to 400	400 to 450	450 to 500	500 to 550	550 to 600	600 to 650	650 to 700	(1)
LG	Liquid gas	up to 450	450 to 500	550 to 600	600 to 650	650 to 700	700 to 750	750 to 800	(1)
N	Coastwise cargo	up to 200	200 to 250	250 to 300	300 to 350	350 to 400	400 to 450	450 to 500	(2)
OB	Combination oil-bulk/ore	up to 450	450 to 500	500 to 550	550 to 600	600 to 650	650 to 700	700 to 800	(1)
P	Passenger (100 or more)	up to 500	500 to 600	600 to 700	700 to 800	800 to 900	900 to 1000	1000 to 1100	(1)
Q	Coastwise passenger	up to 200	200 to 250	250 to 300	300 to 350	350 to 400	400 to 450	450 to 500	(2)
R	Refrigerated	up to 400	400 to 450	450 to 500	500 to 550	550 to 600	600 to 650	650 to 700	(2)
S	Special X	up to 200	200 to 300	300 to 400	400 to 500	500 to 600	600 to 700	700 to 800	(1, 3)
T	Tanker	up to 450	450 to 500	500 to 550	550 to 600	600 to 650	650 to 700	700 to 800	(1)
U	Ferries	up to 100	100 to 150	150 to 200	200 to 250	250 to 300	300 to 350	350 to 400	(2)
V	Towing vehicles	up to 50	50 to 100	100 to 150	150 to 200	200 over			

[1] Larger vessels are designated by successive numbers in 100-foot increments (C8 for 700 through 799 ft, and so forth.
[2] Longer vessels are designated by successive numbers in 50-foot increments (H8 for 600 through 650 ft, and so forth.
[3] The special designation X applies to certain Navy ships built by MARAD and other ships so specialized that they don't fit any other designation.

Table B-5. MARAD Classification of Ship Machinery, Propellers, and Passenger Capability (Group 2).

Machinery Type	Propellers	Passenger Capability 12 and Under[1]	Passenger Capability Over 12[2]
Steam	Single	S	S1
Motor	Single	M	M1
Steam and motor	Single	SM	SM1
Turbo-electric	Single	SE	SE1
Diesel-electric	Single	ME	ME1
Gas turbine	Single	G	G1
Gas turbo-electric	Single	GE	GE1
Nuclear	Single	N	N1
Steam	Twin	ST	S2
Motor	Twin	MT	M2
Steam and motor	Twin	SMT	SM2
Turbo-electric	Twin	SET	SE2
Diesel-electric	Twin	MET	ME2
Gas turbine	Twin	GT	G2
Gas turbo-electric	Twin	GET	GE2
Nuclear	Twin	NT	N2

[1] For triple- and quadruple-screw vessels, add TR or Q respectively to single-screw designation. For example, a triple-screw motor ship is MTR.

[2] For triple- and quadruple-screw vessels, make digit 3 or 4 respectively. For example, quadruple-screw steam is S4.

B-4 NAVSEA DRAWING NUMBERING AND FORMAT

Ship structures and machinery are divided into functional groups by the Expanded Ship Work Breakdown Structure (ESWBS) as described in *Expanded Ship Work Breakdown Structure (ESWBS) for All Ships and Ship/Combat Systems, Volumes 1 and 2 (*NAVSEA S9040-AA-IDX-010/SWBS 5D and S9040-AA-IDX-020/SWBS 5D). The ESWBS is a comprehensive framework that is used through the ship life cycle to organize and correlate elements for cost, weight, specifications, system function and effectiveness, design, production, and maintenance studies. Numbering systems for ship's drawings and related documents, general and contract specifications, ship's weight groups, and the NAVSEA Technical Manual (NSTM) are based on the ESWBS.

B-4.1 Ship Work Breakdown Structure (SWBS). SWBS groups are defined by basic function. The functional segments of a ship, as represented by a ship's structure, systems, machinery, armament, outfitting, etc., are classified by a system of 3-digit numeric groups. There are ten major groups, the last two of which are utilized primarily for cost estimating and progress reporting. The major functional groups are:

000	General Guidance and Administration
100	Hull Structure
200	Propulsion Plant
300	Electric Plant
400	Command and Surveillance
500	Auxiliary Systems
600	Outfit and Furnishings
700	Armament
800	Integration/Engineering
900	Ship Assembly and Support Services

B-4.1.1 Subgroups and Elements. Each major SWBS group (000, 100, 200, 300, etc.) is broken down into subgroups (110, 320, 450, etc.) that are further subdivided into elements (101, 112, 215, etc.). An example of this structure is illustrated below:

(Group)	100 - Hull Structure
(Element)	101 - General Arrangement-Structural Drawings
(Subgroup)	110 - Shell and Supporting Structure
(Element)	111 - Shell Plating, Surface Ship and Submarine Pressure Hull
(Element)	112 - Shell Plating, Submarine Nonpressure Hull
(Subgroup)	120 - Hull Structural Bulkheads
(Element)	121 - Longitudinal Structural Bulkheads
(Element)	122 - Transverse Structural Bulkheads

Since the SWBS is an hierarchical system, the level of subcategorization is flexible. For example, group 100 (Hull Structure) includes a subgroup 120 (Hull Structural Bulkheads) with elements 121 (Longitudinal Structural Bulkheads) and 122 (Transverse Structural Bulkheads). In the General Specifications for Ships, however, Section 120 covers all structural bulkheads, and there is no Section 121 or 122.

Elements X01 through X09 in each group are used only for numbering drawings and specifications sections of a general nature associated with the group. Thus, Booklets of General Plans for ships are in group 801, and ship specification section 503 provides general specifications for pumps for all auxiliary systems.

Volume 2 of the *ESWBS* alphabetically lists Ship Work Breakdown Structure (SWBS) items, the SWBS element title of the items, and the SWBS element number of the items. The first digit of the SWBS element number will correspond to the first digit of the functional group.

B-4.2 Drawing Numbering and Cataloging. Ships' drawings are identified by titles and drawing numbers. The title is the noun name of the system or component to which the drawing applies, or the common name applied to the data provided, i.e., Curves of Form, Cross Curves of Stability, Molded Lines, etc. Many documents not normally thought of as drawings, such as inclining experiment reports, stability and loading data booklets, offset tables, etc., are numbered and handled as drawings. A complete drawing number consists of the ships type designator and hull number (FFG-7, ARS-52, etc) followed by an index number, followed by a specific drawing number. The drawing index number is the SWBS functional group of the ship's component systems to which the drawing applies. Drawing numbers are assigned to specific drawings within an index group. Revisions are indicated by letters (A, B, etc.) appended to the drawing number.

Table B-6 (Page B-14) lists the noun names and functional groups of drawings commonly required in salvage.

The Ship Drawing Index (SDI), formerly called the Ship's Plan Index (SPI), lists the drawings for a particular ship by SWBS group. Each functional group section lists drawings in numeric sequence. The SDI will indicate the most recent drawing revision.

The SDI or SPI is maintained in the ship's log room or technical library, or the technical libraries of repair or design activities.

Table B-6. Functional Groups of Commonly Used Drawings.

Noun Name	SWBS Group, Subgroup, or Element	Noun Name	SWBS Group, Subgroup, or Element
Access Plates	100		
Bilge Keels	114	Nonstructural bulkheads	621
Boat stowage and handling	583, 584	Piping and Liquid Systems	
Bonjean's Curves	801	Drainage and ballast, surface ships	529
Bow Doors	100	Drainage and ballast, submarines	563
Bulkheads, Structural	120	Firemain	555
Longitudinal	121	Seawater service	521
Transverse	122	Fuel	541
Trunks	123	Gasoline/JP-5	542
Blkhds in torpedo protection systems	124	Overflows, air escapes, sounding arrangements	506
Submarine hard tanks	125	Freshwater service	532
Cargo Handling systems	573	Plumbing and deck drains	528
Cargo stowage	673	Compressed air and gas	551, 552
Cross curves of stability	801	Steam	253
Curves of Form	801	Condensate and feedwater	255
Diving Planes	562	Prop machinery cooling water	256
Docking Plan	803	Special piping	558
Electrical power distribution	320	Propeller and Hydrofoil Guards	600
Switchboards and panels	324	Propellers	245
Lighting systems, general	331	Protective Plating	164
General arrangement drawings	801	Rudders	500
General arrangement structural drawings	101	Sea Chests	114
Hull Decks	130	Shaft Struts	100
Main deck	131	Shafts, Propulsion	200
Second through fourth decks	132-134	Shell and supporting structure	110
Fifth deck and below	135	Shell plating, surface ship/submarine pressure hull	111
Hull Platforms	140	Shell plating, submarine nonpressure hull	112
First through fourth platforms	141-145	Inner bottom	113
Flats	149	Shell appendages	114
Hull Fittings	611	Stanchions	115
Inclining Experiment or Trim Dive	097	Framing for shell and inner bottom	116
Interior communications systems	430	Sonar Domes	100
Lines Plan	101	Stabilizing Fins (Surface Ships)	560
Machinery control systems	202, 252	Transducers, Hull Mounted	400
Mooring and towing systems	582	Weight control for surface ships	096

B-4.3 Drawing Format. In addition to the engineering data provided by drawings, there are standard blocks and elements common to all drawings that provide information important to identifying and using the drawings. The following paragraphs review the general information found on all drawings, but are not intended to teach drawing reading and interpretation. Detailed instruction on reading and interpreting drawings may be found in NAVSUP 0502-LP-050-3875, *Blueprint Reading and Sketching*.

B-4.3.1 Title Block. The title block is located in the lower right hand corner of the drawing and contains all the information necessary to identify the drawing. The block designations listed below are keyed to the callouts on Figure B-7.

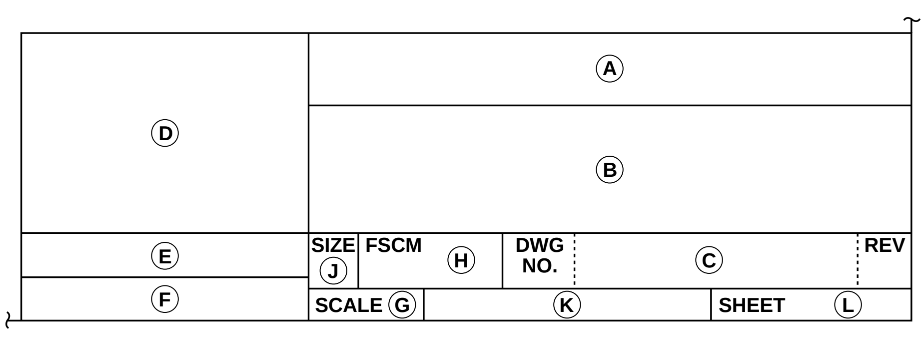


Figure B-7. Standard NAVSEA Drawing Title Block.

- Block A. Name and address of the company or design activity for whom the drawing is prepared.
- Block B. Drawing title. The noun name of the component or system represented by the drawing.
- Block C. Drawing number. This block may be subdivided to separate the drawing index number from the specific drawing number and includes a revision square at the right. The number shown on the drawing may omit the ship type designation and hull number.

- Block D. This block provides information relative to the preparation of the drawing and includes such information as names of the draftsman, checker, and approving authority and the issue date and contract number. This block is optional for continuation sheets.

- Block E. This block records approval by the design activity where different from the preparing activity.

- Block F. This block displays any additional approval required. Blocks E and F may be absorbed into Block D if not required.

Table B-7. Standard Drawing Sheet Sizes.

Flat Sizes			Roll Sizes			
Size	Width (vertical) in.	Length (horizontal) in.	Size	Width (vertical) in.	Length (horizontal) in.	
					Minimum	Maximum
A (Horiz)	8.5	11	G	11	22.5	90
A (Vert)	11	8.5	H	28	44	143
B	11	17	J	34	55	176
C	17	22	K	40	55	143
D	22	34				
E	34	44				
F	28	40				

- Block G. Predominant scale of the drawing.

- Block H. Federal Supply Code for Manufacturers. This is a code identification of the design activity whose drawing number is assigned. NAVSEA drawings will have the number 53711 in this block.

- Block J. Drawing size letter designation. Drawing sizes range from A, the smallest, to K, the largest. The letter designations identify drawing dimensions as shown in Table B-7.

- Block K. Actual or estimated weight of the system or component described.

- Block L. Sheet number for multiple sheet drawings.

B-4.3.2 Revision Block. The revision block, located in the upper right corner of the drawing, is used to record revisions made after the drawing is issued. In this block, all revisions are described, dated, and identified by a letter. This letter is also added to the zone (Paragraph B-4.3.6) of the drawing affected by the change and to any note generated by the change.

B-4.3.3 Reference Block. The reference block, located to the left of the title block, lists numbers for drawings of systems or components that are closely associated with the subject of the drawing, such as adjacent structures or supporting systems.

B-4.3.4 List of Materials Block. The list of materials block, located above the title block, provides a list of parts and materials for the item in the drawing. The list of materials identifies the quantity needed, the specification, and the stock or manufacturer's part number.

B-4.3.5 General Notes. General notes provide written information that cannot be shown graphically on the drawing. This information usually explains painting, heat treating, welding, or any general data the designer wants to convey. General notes are listed in numerical sequence near the top of the drawing and to the left of the list of materials.

Notes are called out on the drawing where they apply. A circled letter by the note number indicates that the note was generated by a revision.

B-4.3.6 Zone Identification. Drawings are divided into zones similar to road map zones by numbers and letters on the borders.

B-4.4 Obtaining and Using Ship's Drawings. Navy ships carry an abridged drawing set, called the *selected record drawings*, consisting of the drawings used most often by ships force. On newer ships, the bulk of the selected record drawings are provided on aperture cards (microfilm). Before depending on use of a ship's selected record drawings the salvage engineer should ensure that he has access to a working aperture card reader-printer. Lens for ordinary microfiche readers can not view an entire aperture card film.

Drawings for Navy ships and craft can also be obtained from the following activities:

- Planning Yards.
- NAVSEA Code 03H3 (Hydrodynamics Division), Code 03P2 (Structural Integrity Division).
- Supervisors of Shipbuilding Conversion and Repair (SUPSHIP).
- Planning and Engineering for Repair and Alterations Activities (PERA).
- Shore Intermediate Maintenance Activities (SIMA).
- Tenders (AD, AR, AS).
- Parent Squadron.
- Military Sealift Command Headquarters, Code N721, Naval Architect Branch, (for MSC ships).
- NAVSEA Supervisor of Salvage (00C).

Table B-8 gives planning yard assignments for Navy ships and craft. Planning yards maintain complete drawing files for assigned ships in addition to the SDI. Other repair activities generally maintain more limited drawing sets, commensurate with the activities maintenance capabilities and responsibilities, and the visit frequency of the ship type. For example, a shipyard in the ship's homeport will usually maintain a nearly complete set of drawings, because of her ability to perform weight and moment studies and plan major alterations in addition to routine repair work. The technical library of an intermediate maintenance activity (IMA), on the other hand, would concentrate on technical manuals and system drawings for assigned ships. An IMA would have little use for Bonjean's Curves, Curves of Form, cross curves of stability, and similar documents, and probably would not maintain them for assigned ships.

Table B-8. U.S. Navy Planning Yard Assignments.

Ships											
Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard
AD 14	14-19	CHASN	AGF 11	11	S-BOST	APL 17		PUGET	CA (all)		PHILA
AD 24		CHASN	AO 51	51-99	S-BOST	AR 5	5-8	CHASN	CG 10		S-BOST
AD 26		CHASN	AK 237		CHASN	ARS 6		PEARL	CG 16	16-24	PUGET
AD 37	37-38	CHASN	AK 251		CHASN	ARS 38	38-43	PEARL	CG 26	26-34	PUGET
AD 41	41-44	CHASN	AK 279		CHASN	ARS 50	50-53	PEARL	CG 47	47-55	S-PASC
AE 21	21	CHASN	AK 282		CHASN	ARVE 3		NORVA	CGN 9	9	NORVA
AE 21	22	PUGET	AO 105		S-BOST	AS 11	11-18	CHASN	CGN 25	25	NORVA
AE 23	23,25	CHASN	AO 177		PUGET	AS 19	19	CHASN	CGN 35	35	PUGET
	24	PUGET	AOR 1	1	PUGET	AS 31	31,32	CHASN	ATF 96		PEARL
AE 26	26-35	PUGET	AGS 26		PHILA	AS 33	33,34	CHASN	T-ATF 166		PEARL
AFS 1	1-7	PUGET	AGS 29		PHILA	AS 36	36,37	CHASN	CGN 36	36,37	NORVA
AG 153		NORVA	AGS 33		PHILA	AS 39	39-41	CHASN	CGN 38	38-40	NORVA
AGM 9		NORVA	AGSS 555		MARE	ASR 9	7-15	PEARL	CV 41	41	PUGET
AGOR 8		PHILA	AOE 1	1-4	PUGET	ASR 21	21,22	CHASN		43	NORVA
AGSS 469		PHILA	AOG 1		PEARL	ATS 1	1-3	PEARL	CV 59	59,60,62	NORVA
AH (all)		NORVA	AOG 76		PEARL	ATF 66		PEARL		61	PUGET
AGS 25		PTSMH	AOG 81		PEARL	ATF 81		PEARL	CV 19		PUGET
AGS 21		PHILA	APL 41		PUGET	AVM 1		LBECH	CVS (all)		PUGET
AGDS 2	2	MARE	APL 53		PUGET	AVT 16		NORVA	CV 63	63,64	PUGET
AGF 3	3	S-BOST	APL 2		PUGET	BB 61	61-64	LBECH		66,67	NORVA

Table B-8 (Continued). U.S. Navy Planning Yard Assignments.

Ships (continued)

Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard	Class	Hull Numbers	Planning Yard
CVN 65	65	PUGET	FF 1098	1098	LBECH	MCM 1	1-7	CHASN	SSBN 726	726-733	S-GROT
CVN 68	68,70	PUGET	FFG 1	1-6	LBECH	MSO (all)		CHASN	SSN 575	575	MARE
	69	NORVA	FFG 7	1-54	LBECH	MSB (all)		CHASN	SSN 578	578-584	PEARL
DD 963	963-992,997	S-PASC	LCC 19	19, 20	PHILA	MSC (all)		CHASN	SSN 579	578	PEARL
DD 710		S-BOST	LCC 20	19	PHILA	MSF (all)		CHASN	SSN 583	578	PEARL
DD 825		S-BOST	LHA 1	1-5	LBECH	MSI (all)		CHASN	SSN 585	585	S-GROT
DD 931	931	S-BOST	LHD 1	1-6		PCS 1376		CHASN		588,590	MARE
DD 933		S-BOST	LPD 1		S-BOST	PG 84		LBECH	SSN 593	593-596,	PTSMH
DD 945		S-BOST	LPD 4	4-15	S-BOST	PGH (all)		PUGET		603-607,612,621	PTSMH
DD 948		S-BOST	LPH 2	2-12	PHILA	PHM 1	1-6	S-SEATTLE	SSN 586	586	CHASN
DDG 2	2-24	PHILA	LSD 28	28-35	S-BOST	PTF (all)		LBECH	SSN 587	587	CHASN
DDG 31		PEARL	LSD 16	16-27	NORVA	PT (all)		NORVA	SSN 608	608-611	S-GROT
DDG 37	37-46	CHASN	LST 491		NORVA	SC 1023		MARE	SSN 637	637-670,672-682,	PTSMH
DDG 51		NORVA	LST 542		NORVA	SS 576	576	PEARL		684,686,687	PTSMH
DDG 993		S-PASC	LST 1156	1156-1170	NORVA	SS 580	580-582	PEARL		683	MARE
FF 1037	1037, 1038	LBECH	LST 1173	1177-1178	NORVA	SSBN 616	616-626	S-GROT	SSN 671	671	S-GROT
FF 1040	1051	LBECH	LST 1179	1179-1198	S-BOST	SSBN 627	627-636	S-GROT	SSN 685	685	S-GROT
FF 1052	1097	PEARL	LSM 1		NORVA	SSBN 640	640-659	S-GROT	SSN 688	688-725	S-NEWS

Yard, Service, and Special Purpose Craft

Type	Planning Yard	Type	Planning Yard	Type	Planning Yard	Type	Planning Yard
AFDB	NORVA	YL (INACTIVE)	PUGET	YFRT	PUGET	YRBM	S-BOST
AFDL	NORVA	YCF	CHASN	YGN	LBECH	YRDH	CHASN
AFDM	NORVA	YCV	CHASN	YNG	CHASN	YRDM	CHASN
ARD	NORVA	YDT	S-BOST	YO	LBECH	YRR	CHASN
ARDM	NORVA	YF	PUGET	YOG	LBECH	YRST	S-BOST
ARL	NORVA	YFB	S-BOST	YOGN	LBECH	YSD	CHASN
DSRV	MARE	YFD	NORVA	YON	LBECH	YSR	S-BOST
DSV	MARE	YFN	CHASN	YOS	S-BOST	YTB	S-BOST
IX 501	MARE	YFNB	CHASN	YP	NORVA	YTL	S-BOST
NR 1	S-GROT	YFND	CHASN	YPD	NORVA	YTM	S-BOST
YAG	LBECH	YFNX	CHASN	YR	CHASN	YW	LBECH
YC (ACTIVE)	CHASN	YFRD	PUGET	YRB	S-BOST	YWN	LBECH

U.S. Navy Planning Yard Key

S-BOST	U.S. Navy Supervisor of Shipbuilding, Conversion, and Repair, Boston, MA	S-PASC	U.S. Navy Supervisor of Shipbuilding, Conversion, and Repair, Pascagoula, MI
CHASN	Charleston Naval Shipyard	PEARL	Pearl Harbor Naval Shipyard
S-GROT	U.S. Navy Supervisor of Shipbuilding, Conversion, and Repair, Groton, CT	PHILA	Philadelphia Naval Shipyard
LBECH	Long Beach Naval Shipyard	PTSMH	Portsmouth Naval Shipyard
MARE	Mare Island Naval Shipyard	PUGET	Puget Sound Naval Shipyard
S-NEWS	U.S. Navy Supervisor of Shipbuilding, Conversion, and Repair, Newport News, VA	S-SEATTLE	U.S. Navy Supervisor of Shipbuilding, Conversion, and Repair, Seattle, WA
NORVA	Norfolk Naval Shipyard		

B-4.4.1 Numbering System for Older Drawings. Prior to the establishment of the current SWBS groups, a similar system of one-digit and three-digit groups was used. Like the SWBS, the first digit of each three-digit group indicates the one-digit group to which it belongs. The one-digit groups 1-9 correspond to SWBS functional groups 100 through 900, but the 3 digit group assignments do not match SWBS elements, and there is no equivalent to the SWBS sub-groups. The following general guidelines were used in assigning three-digit groups:

- Within one-digit groups 1 through 7, three digit group assignments are as follows:

  X45 – *General Arrangement – _______________ Drawings*, where the title of the one-digit group appears in the blank.

  X00 through X49 – weight groups, cost estimating, progress reporting, and drawing numbers.

  X50 through X74 – weight groups only.

  X70 through X99 – cost estimating, progress reporting, and drawing numbers.

- Groups 8 and 9 were used for cost estimating and progress reporting, never weights.

- Group 126 was entitled *Compartment Testing* and used only for cost and progress reporting, not weights.

Older drawings may be numbered by this system, rather than the current SWBS. A partial listing of the old three digit groups is given in Table B-9.

B-4.4.2 Type Designator/Hull Number Changes. Type designator and hull number are sometimes changed during the ship's life or planning, so the designator/hull number for a drawing may not correspond the ship type and number. For example, many FFG-7 class drawings are cataloged as PF-109 drawings because that was the designator originally assigned. Similarly, drawings for most FF-1052 class ships are cataloged as DE-10XX.

B-4.4.3 Scaling Dimensions from Drawings. Paper stretches and shrinks as is gains and loses moisture from and to the atmosphere. Significant changes can occur in days or hours when the humidity changes. The scale indicated in the title block should be considered approximate unless verified at the time dimensions are taken. Dimensions should normally be scaled from a scale bar on the drawing, or based on an object of known length on the drawing. The distance between one or several frames can be used as a handy scale on drawings showing frame locations.

Table B-9. Old SWBS Groups.

Group 1 - Hull Structure		**Group 5 Auxiliary Systems**	
100	Shell Plating and Planking	504	Gasoline, HEAF, Liquid Cargo Piping, Oxygen, Nitrogen, Aviation Lubricating Oil Systems
101	Longitudinal and Transverse Framing	505	Plumbing Installations
102	Inner Bottom	506	Firemain, Flushing, Sprinkler, Washdown, and Salt-water Service Systems
103	Platforms and Flats Below Lowermost Continuous Deck	507	Fire Extinguishing Systems
104	Fourth and Lower Continuous Decks	508	Drainage, Ballast, Trimming, Heeling, and Stabilizer Tank System
105	Third Deck	509	Fresh Water System
106	Second Deck	510	Scuppers and Deck Drains
107	Main Deck or Hanger Deck	511	Fuel and Diesel Oil Filling, Venting, Stowage, and Transfer Systems
108	Forecastle and Poop Decks	513	Compressed Air System
109	Gallery Deck	514	Auxiliary Steam, Exhaust Steam, and Steam Drains
110	Flight Deck, Landing Platforms, and Special Purpose Decks above Weather Deck	515	Buoyancy Control System (Flooding and Venting for Submarines)
111	Superstructure	516	Miscellaneous Piping Systems
114	Structural Bulkheads	520	Mooring, Towing, Anchor and Aircraft Handling Systems and Deck Machinery
115	Trunks and Enclosures	521	Elevators, Moving Stairways, Stores Strikedown, and Stores Handling Equipment
116	Structural Sponsons	526	Hydrofoils
120	Sea Chests	527	Diving Planes and Stabilizing Fins
121	Ballast and Buoyancy Units, Fixed or Fluid	528	Replenishment at Sea and Cargo Handling
127	Sonar Dome	545	General Arrangement - Auxiliary Systems Drawings
145	General Arrangement - Structural Drawings	**Group 6 Outfit and Furnishing**	
Group 2 Propulsion		600	Hull Fittings
203	Shafting, Bearings, and Propellers	601	Boats, Boat Stowage, and Handling
207	Main Steam System	603	Ladders and Gratings
208	Feedwater and Condensate System	604	Nonstructural Bulkheads and Nonstructural Doors
209	Circulating and Cooling Water Systems	645	General Arrangement - Outfit and Furnishings Drawings
210	Fuel Oil Service System	**Group 7 Armament**	
211	Lubricating Oil System	701	Ammunition Handling Systems
213	Reactors	702	Ammunition Stowage
214	Reactor Coolant System	703	Special Weapons, Handling and Stowage
215	Reactor Coolant Service Systems	706	Rocket, Missile, and Components Handling Systems
216	Reactor Plant Auxiliary Systems	707	Rocket, Missile, and Components Stowage
217	Nuclear Power Control and Instrumentation	708	Torpedo Tubes
218	Radiation Shielding (Primary)	709	Torpedo Handling and Stowage
219	Radiation Shielding (Secondary)	710	Mine Handling Systems and Stowage
245	General Arrangement - Propulsion Drawings	711	Small Arms and Pyrotechnic Stowage
Group 3 Electric Plant		712	Air Launched Weapons Handling Systems
300	Electric Power Generation	713	Air Launched Weapons Stowage
301	Power Distribution Switchboards	720	Cargo Munition Stowage
302	Power Distribution System (Cable)	745	General Arrangement - Armament Drawings
303	Lighting System (Distribution and Fixtures)	**Group 8 Design and Engineering Services**	
345	General Arrangement - Electrical Drawings	800	Contract Drawings
Group 4 Communication and Control		802	Technical Manuals
401	Interior Communication Systems and Equipment	803	Engineering Calculations
412	Sonar Systems	804	Weighing
445	General Arrangement - Communication and Control Drawings	805	Hull Standard and Type Drawings
		806	Lofting
		810	Mechanical Standard and Type Drawings
		815	Electrical Standard and Type Drawings
		820	Special Drawings for Nuclear System Valves
		Group 9 Construction Services	
		901	Launching
		906	Molds and Templates, Jigs, Fixtures, and Special Tools
		908	Drydocking

B-5 VESSEL CHARACTERISTICS TABLES

The following tables provide class specific data for Navy and Military Sealift Command (MSC) vessels. Tables B-10, 11, and 12 give detailed hydrostatic, weight distribution, and hull structural data for 22 Navy ship classes. Tables B-13, 14 and 15 give more limited data for the remaining Navy and MSC classes. Tables B-16 through B-20 give lateral and frontal wind areas for Navy and MSC ships and craft. Characteristics for typical commercial vessels are given in Paragraph B-6.

Table B-10. General Characteristics and Full Load Hydrostatic Data for Selected Navy Hulls.

Class	AD 37	AE 21	AE 26	AFS 1	AO 177[1]	AOE 1	AOR 1	CG 16	CG 26[2]	CG 27[2]	CG 47[3]	CG 55[4]	CGN 36
Name	Gompers	Suribachi	Kilauea	Mars	Cimarron	Sacramento	Wichita	Leahy	Belknap	Belknap	Ticonderoga	Ticonderoga	California
Stern Type	Transom	Cruiser	Transom	Transom	Transom	Transom	Transom	Cruiser	Cruiser	Cruiser	Transom	Transom	Cruiser
No. Screws	1	1	1	1	1	2	2	2	2	2	2	2	2
SVC SPD, kts	20	20	20	20	20	26	20	32.7	32.5	32.5	33	33	30+
LBP, ft	620	487	540	530	658	770	640	510	524	524	529	529	570
LOA, ft	644	512	564	581.25	700	793	659	533	546.5	546.5	567	567	596
B, ft	85	72	81	79	88	107	96	55	54.83	54.83	55	55	61.1
D, ft	67.5	74.5	47.75	45.83	48	56	56	38.15	38.1	38.1	42	42	40.9
T_m, ft	22	26.6	27.7	25.62	33.06	37.3	34.78	20.62	20.75	19.5	23	22.4	21.68
Δ_{FL}, lton	19627	15682	20130	17382	36798	49934	39387	8536	8960	8268	9962	9636	11637
DWT, lton	6651	5770	9890	7530	25313	31068	26082	2369	2384	2384	2625	2716	1064
trim[5], ft	+6.03	+8.33	-0.69	+2.54	+2.21	-2.05	-0.08	+0.41	-1.11	+0.29	-0.97	-1.08	-0.07
C_{WP}	0.7532	0.7076	0.7578	0.7214	0.7778	0.724	0.7738	0.7296	0.7415	0.7356	0.7575	0.7551	0.7534
C_M	0.9553	0.9652	0.9414	0.9223	0.9792	0.9874	0.9806	0.8284	0.8316	0.8236	0.8465	0.8429	0.8137
C_P	0.6124	0.6078	0.6157	0.6106	0.6842	0.5749	0.6560	0.6203	0.6304	0.6239	0.6144	0.6105	0.6315
C_B	0.5925	0.5885	0.5814	0.5671	0.6728	0.5687	0.6451	0.5165	0.5260	0.5173	0.5211	0.5173	0.5394
LCB, ft	312.93	244.4	270.2	267.2	334.97	390.6	322.5	267.6	272.06	270.10	279.31	278.37	292.5
LCG, ft	324.71	253.7	269.2	270.6	350.43	387.7	322.4	267.6	269.84	270.62	277.39	276.18	292.3
LCF, ft	332.30	252.4	296.2	281.8	337.83	426.8	348.2	289.7	296.54	297.15	306.59	286.86	322.1
*MT*1, lton/in	3178	1411	2378	1944	3969	5815	4069	1382	1494	1470	1635	1625	2077
KG, ft	32.46	24.91	29.62	28.45	28.04	32.19	28.49	20.2	20.3	20.17	23.35	23.22	23.8
KM, ft	40.53	30.24	35.91	34.78	36.33	45.44	40.56	25.2	25.06	25.31	26.53	26.14	28.66
FS, ft	0.73	2.6	2.33	1.83	2.03	0.94	0.19	0.68	0.51	0.55	0.51	0.06	0.09
GM_{corr}, ft	7.34	2.73	3.96	4.5	6.26	12.34	11.88	4.32	4.25	4.59	2.67	2.86	4.77
BM_T, ft	28.38	15.43	20.41	20.48	18.77	24.83	21.79	12.91	12.97	13.82	12.46	12.81	15.23

Class	CGN 38	DD 963N[6]	DD 963V[7]	DD 993	FF 1052	FFG 7	LKA 113	LPH 2	LSD 41	LST 1179	PHM 1[8]	T-AOT 168
Name	Virginia	Spruance	Spruance	Kidd	Knox	Perry	Charleston	Iwa Jima	Whidbey Is	Newport	Pegasus	Sealift
Stern Type	Cruiser	Transom	Transom	Transom	Transom	Transom	Transom	Cruiser	Transom	Transom	Transom	Transom
No. Screws	2	2	2	2	1	1	1	1	2	2	0	1
SVC SPD, kts	30+	33	33	33	27	29	20	23	20+	20	12	16
LBP, ft	560	529	529	529	415	408	550	556	580	500	118.11	560.3
LOA, ft	585	563.3	563.3	563	438	453	578.5	597.67	609.6	522.25	146.65	587
B, ft	63	55	55	55	46.4	46.96	82	84.25	84	68.13	27.56	84
D, ft	41.95	42.0	42.0	42	29.4	30	47.83	47.17	44.5	37	7.55	45.5
T_m, ft	21.5	20.6	21.27	22.7	15.61	15.87	25.675	27.25	19.6	16.17	6.72	34.7
Δ_{FL}, lton	11135	8475	8895	9786	4254	4017	18698	18940	15989	8765	245	34037
DWT, lton	968	2070	2376	2488	1122	929	8563	5883	4948	3596	73	27437
trim[5], ft	-1.5	-1.94	+1.13	-1.2	+0.07	+1.40	-0.09	+2.75	-0.35	-0.17	-2.49	*14.45
C_{WP}	0.7631	0.7453	0.7497	0.7571	0.7417	0.7193	0.7137	0.6682	0.7825	0.7094	0.6687	0.8215
C_M	0.8090	0.8297	0.8349	0.8453	0.8143	0.7350	0.9419	0.9118	0.9410	0.8818	0.5682	0.9920
C_P	0.6377	0.5925	0.6017	0.6132	0.6012	0.6129	0.5988	0.5636	0.6156	0.5468	0.6808	0.7325
C_b	0.5138	0.4949	0.5031	0.5188	0.4953	0.4633	0.5651	0.5193	0.5861	0.5571	0.3925	0.7292
LCB, ft	289.5	272.4	276.0	278.8	208.0	208.10	279.4	288.3	295.4	265.0	68.64	271.0
LCG, ft	285.9	270.1	273.5	276.4	208.1	211.56	279.3	288.2	294.8	264.6	63.88	286.9
LCF, ft	319.3	307.3	307.2	306.7	234.6	227.68	293.8	304.0	328.3	282.8	69.65	282.9
MT1, lton/in	2146	1582	1601	1630	819	786	2063	2082	3132	1550	41	3131
KG, ft	23.58	23.03	22.97	23.27	17.23	18.82	30.11	29.32	32.09	23.22	10.591	25.45
KM, ft	30.06	26.41	26.27	26.12	22.12	22.56	36.57	35.78	43.5	33.69	16.38	34.58
FS, ft	0.34	—	—	—	0.43	0.42	2.34	0.68	0.10	3.18	0.394	1.51
GM_{corr}, ft	6.14	3.41	3.3	2.85	4.46	3.32	4.12	5.78	11.31	7.29	5.394	7.63
BM_T, ft	17.4	12.81	13.65	12.6	13.08	12.75	22.29	20.44	32.59	22.48	11.526	16.42

Notes:

1. Jumboized
2. CG 26 hydrostatic data differs from rest of class (CG 27-34) because of extensive modifications
3. Without VLS
4. With VLS and class modifications, including conversion of voids G-58-1&2 to fuel tanks
5. + by the stern, - by the bow
6. Without VLS
7. With VLS
8. Hull Borne

Table B-11. Weight Distribution for Selected Navy Hulls.

Weight Segment, STN - STN	Weight per segment, lton											
	AD 37	AE 26	AFS 1	AO 177	AOE 1	AOR 1	CG 16	CG 26[2]	CG 27[2]	CGN 36	CGN 38	CG 47[3]	CG 49[3]
FWD - 0	11.06	71.93	58.85	55.14	—		6.56	17.61	23.88	18	11.8	—	-
0 - 1	115.86	253.87	184.52	118.23	128.57	278.51	121.06	192.39	207.87	263	125.0	338.77	315.47
1 - 2	396.75	349.77	394.75	243.24	788.88	343.66	113.17	183.17	190.53	355	365.7	182.02	189.53
2 - 3	460.64	343.78	587.41	385.75	1337.57	969.81	199.75	210.37	225.03	178	280.0	218.91	210.55
3 - 4	586.54	703.42	784.07	1620.26	2556.15	1576.02	190.04	189.50	207.26	255	209.6	315.38	286.07
4 - 5	743.43	1320.80	794.64	1762.89	1988.31	2563.18	333.65	197.25	190.31	286	477.7	500.44	473.57
5 - 6	1148.32	1065.56	751.36	2914.82	2229.96	1581.23	515.85	633.01	520.41	402	193.9	445.13	434.97
6 - 7	1212.21	1395.23	898.75	3284.01	3643.93	2953.52	524.96	613.81	544.74	468	410.1	606.41	574.72
7 - 8	1090.10	1416.70	1250.80	2057.80	4527.54	3618.62	544.62	649.37	589.45	1365	1450.0	625.07	615.29
8 - 9	1432.99	1512.61	1471.59	2587.77	3457.30	2295.89	666.58	626.07	567.88	244	815.0	642.69	626.96
9 - 10	1837.88	1614.50	1088.84	2646.56	4424.67	3931.06	727.27	767.87	647.17	933	860.2	804.53	769.06
10 - 11	1653.77	1560.94	1484.16	1712.00	4498.82	3091.22	773.99	778.88	723.22	1025	1020.8	637.16	651.69
11 - 12	1283.66	1806.69	1187.96	3477.00	4768.38	1641.39	577.41	680.03	527.21	1673	1515.5	691.38	679.04
12 - 13	1952.05	1752.75	1248.80	3589.82	3698.12	4196.56	615.60	736.49	676.50	892	930.3	655.98	646.17
13 - 14	1147.95	1033.47	1319.21	2763.22	1706.76	3442.77	641.83	610.94	514.47	688	484.1	527.17	475.75
14 - 15	1087.84	913.59	1097.41	2581.24	1669.26	1505.78	481.82	332.46	341.71	368	298.5	603.13	597.66
15 - 16	1112.98	949.55	907.32	1509.05	2217.95	1343.06	395.43	298.56	327.64	419	424.3	558.53	538.67
16 - 17	928.87	721.78	486.86	1152.36	2822.45	1159.15	399.17	395.93	402.49	489	423.6	539.72	517.79
17 - 18	729.26	859.64	426.02	905.23	1919.67	1411.25	298.60	383.70	385.47	290	210.0	386.33	396.63
18 - 19	335.90	251.75	316.91	825.75	1212.29	854.43	266.47	304.72	290.94	280	352.8	408.53	406.67
19 - 20	330.04	221.78	366.18	439.16	337.43	629.76	142.16	142.34	120.21	236	275.7	275.64	271.94
20 - AFT	28.85	5.99	275.73	207.18			0.00	15.54	43.16	10	—	—	
SUM	19626.95	20126.08	17382.14	36798.48	49934.01	39386.87	8535.99	8960.01	8267.55	11637	11134.6	9962.92	9678.20
Station spacing, ft	31.0	27.0	26.5	32.9	38.0	32.0	25.5	26.2	26.2	28.5	28.0	26.45	26.45
FP-FWD, ft	16.0	14.0	17.5	12.42	—	-	16.0	19.0	19.0	21.0	20.0	—	—
AP-AFT, ft	7.83	10.0	33.75	-	—	-	7.0	4.01	4.01	5.0	—	—	—

Weight Segment, STN - STN	Weight per segment, lton											
	CG 52[3]	DD 963V[4]	DD 963N[5]	DDG 993	FF 1052	FFG 7	LKA 113	LPH 2	LSD 41	LST 1179[6]	PHM 1	T-AOT 168
FWD - 0	—	—	0.00	0.00	10.25	19.4	10.61	19.61	91.74	85.25	0.99	5.17
0 - 1	297.51	292.63	313.95	341.12	120.81	41.6	56.62	456.07	256.86	133.79	7.35	173.40
1 - 2	182.90	150.77	155.11	176.87	227.12	84.2	304.31	505.59	293.56	166.59	8.43	1056.73
2 - 3	213.48	177.06	200.28	215.29	145.32	108.3	574.47	723.47	348.60	234.50	7.38	1647.47
3 - 4	340.48	296.62	211.84	259.47	114.63	201.6	756.93	782.90	550.42	362.16	8.71	2495.67
4 - 5	523.45	495.39	373.80	468.52	110.53	217.6	1182.41	732.90	688.03	297.84	6.85	1695.06
5 - 6	421.58	356.95	371.98	386.21	281.63	266.3	1163.70	742.80	1247.67	338.48	10.16	1540.06
6 - 7	598.13	554.18	566.12	577.06	277.84	273.2	1398.92	990.40	862.32	502.29	11.50	1913.63
7 - 8	583.96	689.09	697.38	753.01	361.94	190.6	1240.01	1158.77	889.85	605.85	11.96	1567.79
8 - 9	620.55	603.53	609.35	651.18	198.94	189.9	1241.33	1355.56	1178.81	593.86	17.87	1646.83
9 - 10	712.62	697.34	728.05	693.78	270.45	268.2	1070.65	1218.20	1357.70	697.19	19.28	1907.05
10 - 11	631.57	581.52	580.02	689.04	283.75	273.2	1181.16	1218.20	1440.26	592.61	15.86	3235.46
11 - 12	665.08	706.47	712.60	875.02	268.35	246.0	1248.08	1445.99	1178.81	678.79	13.70	1822.03
12 - 13	594.65	619.19	571.36	643.72	218.46	220.2	1429.37	1485.61	1201.75	553.59	13.01	1666.57
13 - 14	439.13	440.53	445.46	487.83	287.16	302.2	1565.81	1366.75	798.11	597.92	13.62	1804.86
14 - 15	542.15	443.78	367.78	551.32	209.86	250.6	1328.91	1049.83	697.20	626.26	7.94	3154.63
15 - 16	513.24	421.31	296.79	495.89	239.97	184.6	927.11	920.69	807.28	403.85	16.78	1869.60
16 - 17	573.08	388.40	360.19	481.80	171.87	207.6	953.40	920.69	550.42	360.35	19.78	1262.69
17 - 18	442.93	313.36	293.75	414.81	162.17	101.8	495.75	668.14	495.38	263.98	12.91	1298.60
18 - 19	413.35	364.79	342.27	366.42	144.98	162.3	366.73	569.10	403.64	212.05	12.36	1384.30
19 - 20	272.71	302.46	276.95	258.06	147.98	120.2	197.57	534.43	651.33	310.35	7.43	658.96
20 - AFT	—		0.00	0.00		25.4	1.50	74.28	—	147.31	1.58	230.29
SUM	9582.51	8895.37	8475.00	9786.42	4254.01	3955.0	18695.35	18940	15989.00	8764.86	245.46	34036.85
Station spacing, ft	26.45	26.45	26.45	26.45	20.76	20.4	27.5	27.8	29.0	25.0	5.9	28.02
FP-FWD, ft	—	—		—	17.5	30	16	15.64	29.6	28.9	17.72	—
AP-AFT, ft	—	—		—	—	12.5	7.5	20.56	—	25.0	—	—

Notes:

1. LCG of each segment assumed to lie at midlength.
2. CG 26 weight distribution differs from rest of Class (CG 27-34) because of extensive modifications during repair of major collision/fire damage.
3. CG 47-51 without VLS (MK 26 Launchers installed), CG 49-51 distribution reflects structural modifications, CG 52-54 distribution with VLS; CG 55 voids G-58-1 and 2 converted to fuel tanks and other class modifications increase segment 2-3 to 243.13 lton, Segment 3-4 to 360.83 lton, and total weight to 9632.51 lton.
4. With VLS.
5. Without VLS.
6. Weight FWD of FP can be broken into 2 segments: 0-A (25 ft), 59.68 lton and A-B (12.5 ft), 6.94 lton.

Table B-12. Section Structural Properties for Selected Navy Hulls.

STN	AD 37		AE 26[1]		AFS 1		AO 177 (PRE-JUMBO)		AO 177 (JUMBO)		AOE 1		AOR 1		CG 26		CG 47/ DD 963/DDG 993	
	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}	Area	I_{NA}
	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2	in^2	in^2-ft^2
3	2935	1503730		501144	1848	532126		461799		570979	2692	1793278		1762681	1250	269948	1283	289294
4	3105	1744129	2661	1244685	2350	743426		704020		866632	3900	2307022		1822103	1312	269256	1551	253896
5	3990	2227674			2692	886968		954888		1138948	3033	3088902		1881523	1518	358855	1418	237662
6	4372	2653976			2964	997226		1138948		1307798	7601	4548346		1940945	1834	414277	1494	268673
7	4792	2729846			3036	1031260		1307798		1354487	8477	3154622		2123591	1820	420478	1993	390860
8	4583	2875386			3039	1041100		1340100		1647243	9147	5655330		2306237	1785	396368	2180	437978
9	4686	2749630			3185	1079167		1386367		1898494	10244	5924020		2300851	1932	431596	2166	469049
10	4468	2642772	3129	1436428	3141	1087303		1371551		1899772	10235	6094704		2295466	1959	426485	2285	507174
11	4553	2682599			3292	1095581		1393672		1930496	9956	5931128		2244522	1936	418194	2207	530546
12	4356	2535051			3357	1132636		1318525		1930496	8340	5370772		2193579	1873	379286	2502	565247
13	4433	2545400			2907	983148		1228323		1747562	6945	4640580		2073571	1894	382034	2233	470365
14	3803	2210973	2670	1478116	2812	910917		1144270		1379669	6820	4101110		1953562	1840	348013	1812	351737
15	4109	2237001			2742	832672		1033741		1125537	6842	3426348		1549667	1399	172114	1946	273155
16	3645	1853473			2439	616104		753915		1013958	5057	2280510		1145772	1192	112765	1541	166202
17	3396	1563959	1739	175730	2154	509985		636728		667250	4668	1610132		741877	1088	76734	1518	104119
	Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:	
	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel
3	30.08	39.58			18.84	29.24	23.60	25.40	23.46	25.54	31.29	37.01	23.90	33.57	19.33	25.21	18.58	26.81
4	32.06	36.93	30.4	31.6	19.14	28.46	22.76	26.24	22.86	26.14	32.40	34.80	25.96	30.04	19.40	23.85	21.58	22.22
5	33.13	35.03			20.51	26.69	22.51	26.49	23.07	25.93	33.57	33.13	28.24	27.34	20.88	21.43	22.14	20.16
6	33.69	34.38			21.28	25.52	23.07	25.93	24.47	24.53	32.39	34.11	30.78	25.22	20.88	20.48	20.94	22.06
7	34.36	33.38			22.59	24.01	24.47	24.53	24.60	24.40	34.03	32.47	26.22	25.95	21.60	18.96	24.00	18.00
8	32.69	34.80			23.40	23.00	24.60	24.40	25.05	23.95	34.00	32.50	23.31	26.60	21.99	18.07	24.18	17.82
9	36.50	30.99			23.84	22.46	24.43	24.67	24.63	24.37	35.09	31.41	26.03	26.56	21.49	18.07	21.93	20.07
10	38.35	29.14	34.22	24.03	24.47	21.83	24.68	24.32	24.62	24.38	34.82	31.68	29.49	26.51	20.92	18.24	22.24	19.76
11	37.50	29.99			25.12	21.18	24.35	24.65	24.35	24.65	34.67	31.83	30.05	25.93	20.50	18.36	22.90	19.10
12	38.31	29.18			23.95	22.35	24.44	24.56	24.35	24.65	34.15	32.35	30.66	25.34	20.70	18.06	25.20	16.80
13	36.01	31.48			23.09	23.21	23.57	25.43	24.89	24.11	34.23	32.27	29.16	26.68	19.50	19.26	23.21	18.04
14	37.76	29.73	37.1	22.7	21.48	24.82	23.74	25.26	24.24	24.76	33.00	33.20	27.64	28.36	19.21	19.65	21.07	17.85
15	33.28	34.21			18.70	27.70	26.28	27.72	24.63	24.37	28.87	35.33	25.67	29.95	21.06	17.00	20.45	16.13
16	34.14	33.35			17.12	29.48	25.14	23.86	25.30	23.70	26.50	33.70	22.88	33.12	12.92	17.14	21.00	13.25
17	30.41	37.08	9.4	21.6	16.92	29.98	21.46	27.54	23.08	25.92	24.00	31.00	18.65	42.52	10.90	13.49	21.14	10.86

Table B-12 (Continued). Section Structural Properties for Selected Navy Hulls .

STN	CGN 38		CV 59		FF 1052		FFG 7		LHA 1[2]		LKA 113		LPH 2		LSD 41		LST 1179	
	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2	Area in^2	I_{NA} in^2-ft^2
3		335645	12358	16758326	868	108027	711	110681		4442540	1874	675724	3069	1716649	2004	796874	1038	142777
4		342358	16591	17177298	977	127318	745	112994		5401509	2360	1160403	3698	2623881	1875	884862	976	175019
5		409487	11790	13148127	1086	139464	761	102384		6130713	2712	1052732	4101	3030117	1972	970102	1096	226705
6		510180	17790	18535837	1064	133392	936	136770		6556756	3073	1162720	4591	3306753	3192	1534690	1490	272382
7		597448	19446	18836764	1068	136068	935	130123		7286723	3303	1230578	4712	3755656	4098	1867936	1930	342501
8		497448	17352	19168785	1015	136471	1007	138267		6916758	3710	1200108	5194	3775892	4023	1433109	2135	382825
9		644438	17887	20669502	1100	156278	1125	159477		6725151	3517	1328462	5252	3800192	3824	1408479	2323	432689
10		671290	18220	20999949	1055	150946	1198	170416		7078395	4013	1495658	5199	3882010	4279	1464853	2295	434270
11		678003	18470	21293683	1054	149046	1203	167165		7299516	4291	1520460	5696	4070689	4234	1412839	2562	529612
12		671290	17892	19807975	1110	154588	1178	156553		7109088	4218	1512998	5400	4123254	3739	987907	2195	486630
13		637726	17563	19383215	1111	138854	1055	135444		7002391	3358	1272356	5108	3834913	3896	972030	2275	424229
14		449764	21122	20161029	1090	117773	970	110066		6541561	3176	1198935	4422	3246058	3202	701956	1932	360794
15		328932	18349	17624328	989	87112	922	89467		6407861	4406	1157017	3980	2621274	2820	508752	2030	320766
16		255090	16763	15829157	932	62643	861	69084		6152574	2798	703870	3238	2093116	3532	416856	2078	325149
17		201387	13698	12068113	954	56332	809	57188		5284773	2442	514961	3227	1740634	2167	282624	1711	230461

STN	CGN 38		CV 59		FF 1052		FFG 7		LHA 1[2]		LKA 113		LPH 2		LSD 41		LST 1179	
	Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:		Distance (ft) from Neutral Axis to:	
	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel	Deck	Keel
3			39.40	58.01	16.48	17.10	15.09	20.58	38.07	52.43	24.65	26.90	28.04	48.86	28.75	32.76	15.37	19.87
4			41.96	52.45	14.73	18.02	15.68	18.84	42.41	48.09	24.54	26.01	34.95	41.96	31.19	30.31	16.06	19.43
5			48.76	48.64	13.17	18.66	14.18	19.27	45.00	45.10	23.95	25.75	41.20	35.71	32.25	29.25	16.31	19.33
6			48.35	48.89	13.88	17.20	15.32	17.23	46.75	43.75	23.35	25.60	42.94	33.97	30.32	31.18	18.78	17.21
7			49.07	48.33	13.80	16.70	15.37	16.38	49.87	40.63	23.40	24.85	42.13	34.78	34.75	26.75	17.87	18.37
8			48.74	48.66	13.67	16.25	15.53	15.59	50.97	39.53	24.90	22.93	45.64	31.27	31.20	21.67	18.46	18.03
9			48.95	48.45	13.95	15.55	15.36	15.21	52.63	37.87	25.50	22.33	46.49	30.42	31.54	21.39	19.21	17.53
10	20.36	21.49	48.97	48.42	14.53	14.72	14.62	15.45	51.59	38.91	25.91	21.92	45.33	31.58	31.96	21.04	19.53	17.46
11			49.43	47.97	14.48	14.60	14.16	15.51	50.88	39.62	24.19	23.64	46.17	30.74	31.84	21.05	19.32	17.92
12			49.63	47.77	13.55	15.25	14.27	15.10	50.13	40.37	24.64	23.19	45.32	31.59	25.99	18.51	19.50	18.00
13			48.66	48.73	13.34	14.99	15.00	14.27	48.66	41.84	24.65	23.18	43.80	33.11	26.11	18.39	18.80	18.49
14			51.01	46.39	13.03	14.50	12.87	15.29	47.89	42.61	23.62	24.21	39.92	36.99	23.53	20.92	19.63	16.86
15			42.84	49.56	12.60	13.47	11.70	14.83	47.00	43.50	23.02	24.81	35.89	40.92	23.66	19.09	18.34	16.45
16			45.10	52.21	11.87	12.38	10.12	14.32	44.79	45.71	19.22	26.11	31.92	44.99	21.67	18.30	15.27	17.62
17			39.21	58.19	11.39	10.86	9.46	13.07	42.29	48.21	15.01	23.66	28.40	48.49	20.23	16.59	12.57	17.62

NOTES:

1. AE 26 data for Stations 4/9, 4 2/9, 10, 13 8/9, 17 7/9.
2. Y_{DECK} measured to flight deck.
3. For any intact station:

$$Z_{KEEL} = \frac{I_{NA}}{Y_{KEEL}}$$

$$Z_{DECK} = \frac{I_{NA}}{Y_{DECK}}$$

$$DEPTH = Y_{DECK} + Y_{KEEL}$$

Table B-13. Hull Characteristics, Auxiliaries.

Class	L_{WL}	B_{WL}	T_m	Displacement, lton		TPI	Class	L_{WL}	B_{WL}	T_m	Displacement, lton		TPI
	ft	ft	ft	full load	light	lton/in		ft	ft	ft	full load	light	lton/in
AD 14	520	73	26.0	18400	9240	67.0	AOE 1	770	107	41.0	53600	18870	128.0
AD 24	465	70	27.0	16740	8800	58.0	AOG 58	292	49	16.0	4440	1800	27.0
AD 37	620	85	27.0	20500	13600	89.0	AOG 77	315	48	19.0	6050	2100	29.0
AD 41	620	85	22.1	19740	13220	95.0	AOG 81	295	61	22.2	6970	2370	29.0
AE 21	492	72	29.0	17450	9910	61.0	AOR 1	640	96	36.5	37700	12500	102.5
AE 26	540	81	28.0	19670	9450	71.5	AOT 50	510	68	30.0	21880	5250	67.0
AF 58	486	72	26.5	15500	8450	56.0	AOT 149	600	84	33.6	34760	7880	90.0
AFS 1	554	79	28.0	18660	9170	67.0	AOT 165	605	80	36.0	32700	8400	81.0
AG 153	537	76	27.0	17960	14200	67.0	AOT 168	572	84	34.5	34500	6600	85.0
AG 164	437	66	21.8	11150	7350	47.0	AOT 181	600	84	33.7	34800	7330	90.0
AGDS 2	448	72	22.6	12420	10890	61.0	AOT 182	650	89	36.2	45880	8600	109.0
AGER 2	171	32	10.0	945	610	9.3	AP 110	590	76	26.0	20750	12600	77.0
AGF 3	500	84	23.0	13900	8000	85.0	AP 122	590	76	29.1	22570	10800	74.0
AGM 8	445	62	28.5	15200	8280	49.0	AP 197	512	73	27.0	17630	11220	61.0
AGM 9	502	72	26.3	17120	14000	60.0	APL 2	260	49	10.0	2580	1300	26.0
AGM 19	575	75	27.1	24710	13770	80.0	AR 5	520	73	24.0	17200	9320	66.0
AGM 22	445	62	23.5	12170	8850	48.0	ARC 2	340	47	25.1	7810	4300	29.0
AGM 23	528	76	27.0		12980	63.0	ARC 3	402	58	16.0	7040	4280	42.0
AGOR 7	196	39	16.3	1640	1230	12.	ARC 7						
AGOR 11	247	51	18.0	3510	2510	40.0	ARL 24	316	50	14.0	4330	2220	33.0
AGOR 16	218	75	20.1	3420	2870	18.0	ARS 8/38	207	43	14.3	1970	1470	14.3
AGOS 1							ARS 50	240	50	26.0	3100	2500	22.9
AGS 21	445	62	25.0	13050	7610	48.0	AS 11	520	73	26.0	17150	9960	65.0
AGS 26	267	48	16.0	2830	2200	21.0	AS 19	564	73	26.0	20300	14190	75.0
AGS 29	362	54	15.0	3670	2640	33.0	AS 31	581	83	26.0	19820	12100	81.0
AH 17	496	72	26.0	15400	11400	60.0	AS 33	620	85	28.0	21530	19580	96.0
AK 237	445	62	28.5	15200	4520	47.0	AS 36	620	85	29.0	23490	13840	98.0
AK 255	506	72	32.8	22050	8580	61.0	AS 39	620	85	26.0	23000	13840	98.0
AK 271	235	51	19.0	3890	2020	17.0	ASR 9	247	42	17.0	2320	1790	16.0
AK 277	456	66	30.0	16730	5740	50.0	ASR 21	237	86	23.9	4910	4100	23.0
AK 280	450	63	28.5	15200	6820	48.0	ATA 181	201	34	14.0	860	610	8.0
AKR 7	484	78	27.1	18290	8180	64.0	ATF 76	201	39	16.0	1730	1240	12.0
AKR 9	520	83	29.1	21580	9150	72.0	ATS 1	264	50	17.0	3060	2170	24.0
AO 57	544	75	32.0	25450	7470	74.0	AVM 1	520	71	27.3	14480	10820	64.0
AO 51	616	75	38.0	34750	10850	92.0	AVT 16	828	103	30.0	42110	29780	146.0
AO 105	636	75	35.8	35650	9450	86.0							
AO 143	642	86	33.6	36660	11750	96.4							
AO 177	568	88	32.4	27500	7240	84.0							

Notes:
1. L_{WL} = Length on full load waterline, B_{WL} = breadth on full load waterline, T_m = mean draft at full load
2. Displacements within the same class may vary. Values are for maximum and minimum displacements of any vessel in the class.

Table B-14. Hull Characteristics, Surface Combatants.

Class	L_{WL} ft	B_{WL} ft	T_m ft	Displacement, lton full load	Displacement, lton light	TPI lton/in	Class	L_{WL} ft	B_{WL} ft	T_m ft	Displacement, lton full load	Displacement, lton light	TPI lton/in
BB 61	860	108	37.0	58000	43880	149.0	DDG 37	490	52	18.0[4]	6120	4150	43.0
CA 134	700	75	26.0	21470	16000	94.0	DDG 47	530	55	20.0	8910	6570	48.5
CG 10	664	69	26.0	19500	13200	82.0	DD 993	529	55	22.7	9788		52.4
CG 16	510	54	19.0	8750	4650	47.5	FF 1037	350	41	15.0	2730	1970	24.0
CG 26	524	54	20.5	8250	5340	48.5	FF 1040	390	44	17.0	3580	2620	28.5
CG 47	529	55	23.0	9960		52.5	FF 1052	415	47	16.5	4330	2850	32.5
CGN 9	690	72	25.0	17530	15540	86.0	FF 1098	394	43	17.0	3660	2760	29.0
CGN 25	540	57	21.0	8590	7800	54.0	FFG 1	390	44	17.0	3600	2630	28.5
CGN 35	540	57	20.4	9130	8320	56.0	FFG 7	408	38	14.4	3590	2980	30.0
CGN 36	570	60	21.0	10450	8710	60.0	LCC 19	580	82	29.0	18650	11600	
CGN 38	560	61	21.8	10420	8620	64.0	LHA 1	765	106	26.0	39400	25330	164.0
CV 34	831	103	32.0	45110	32520	147.0	LHD 1						
CV 41	914	121	35.0	65240	48130	188.0	LKA 112	536	76	27.0	17500	9860	66.0
CV 59	990	130	38.0[3]	81150	59020	230.0	LKA 113	550	82	28.0	18650	10000	76.0
CV 63	990	130	37.0	81770	58600	230.0	LPA 249	537	76	26.0	17550	10710	66.0
CV 67	990	130	37.0	80940	59180	230.0	LPD 1	508	84	23.0	14670	8000	85.0
CVA 31	820	103	31.0	43110	30940	146.0	LPD 4	557	84	23.0	17240	8600	85.0
CVN 65	1040	133	38.0	90950	73500	252.0	LPH 2	556	84	28.0	18830	10720	75.0
CVN 68	1056	134	38.0	91490	70920	252.0	LSD 28	500	84	19.0	12150	6880	68.0
CVS 11	820	103	31.	41900	29600	146.0	LSD 36	548	84	20.0	13700	8100	76.0
DD 743	383	40	15.0	3550	2340	29.0	LST 963	316	50				
DD 931	407	44	16.0	4200	2800	33.0	LST 1173	431	62	18.0	7100	3560	55.0
DD 937	407	44	16.0	4140	2800	33.0	LST 1179	507	70	16.0	8520	4750	57.0
DD 963	529	55	21.0	7810	5770	51.0	MCM 1						
DDG 2	420	46	16.0	4900	3100	37.0	MSO 427	165	35	10.0[5]	930	620	10.0
DDG 31	407	44	16.0	4200	2860	33.0	PG 92	154	22	6.0	280	200	6.0
							PHM 1	118	25	8.0	210	160	6.0

Notes:
1, 2. See Table B-13.
3. Full load draft for CV 60 & 62 – 37.0 feet, for CV 61 – 41.0 feet.
4. DDG 37 full load draft – 19.0 feet.
5. Full load drafts vary from 10 to 12 feet.

Table B-15. Hull Characteristics, Submarines.

Class	L_{WL}/LOA ft	B_{WL}/B_E ft	T_m ft	Displacement lton full load	Displacement lton light	TPI lton/in	Class	L_{WL}/LOA ft	B_{WL}/B_E ft	T_m ft	Displacement, lton full load	Displacement, lton light	TPI lton
AGSS 555	159/165	16/18	15.6	860	800	3.9	SSN 575	370/376	22/28	22.3	4400	4040	16.1
AGSS 569	187/205	25/27	19.0	1540	1240	7.0	SSN 578	260/263	20/25	20.8	2580	2380	9.1
NR 1	128/136	16/16	11.1	352	337	1.9	SSN 585	232/249	28/32	25.1	3070	2850	9.0
SS 565	290/293	24/27	16.8	2030	1740	12.4	SSN 586	445/448	34/37	24.0	5940	5480	30.0
SS 574	332/334	25/30	18.3	2940	2560	16.0	SSN 587	350/350	24/26	21.0	3920	3570	
SS 576	282/283	25/27	16.8	2030	1740	12.4	SSN 588	230/249	25/32	25.2	3080	2870	9.6
SS 580	209/219	27/29	20.6	2150	1740	10.1	SSN 594	257/279	27/32	25.5	4010	3750	11.3
SSAG 567	290/293	24/27	16.8	2030	1740	12.4	SSN 597	262/273	19/23	19.4	2610	2150	7.0
SSBN 598	348/382	25/33	27.5	6030	5420	14.0	SSN 603	265/297	27/32	25.5	4010	3750	11.3
SSBN 608	378/411	26/33	27.5	6950	6320	17.5	SSN 637	283/303	25/32	25.8	4270	3860	12.0
SSBN 616	395/421	25/33	27.3	7350	6700	17.0	SSN 671	286/315	25/33	27.7	5290	4950	12.5
SSBN 726	500/559	30/42	35.4	16740	14710	32.1	SSN 685	340/365	25/32	26.4	5780	5420	16.4
SSN 571	320/324	23/28	22.1	3570	3230	10.2	SSN 688	342/361	32/33	27.2	6930	5720	17.0

Notes:
1. L_{WL} = Length on full load waterline, LOA = length overall, B_{WL} = breadth on full load waterline, B_E = extreme breadth, T_m = mean draft at full load.
2. Displacements within the same class may vary. Values are for maximum and minimum displacements of any vessel in the class.
3. See Table B-13.

Table B-16. Windage Areas[1], Auxiliaries.

Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²			Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²		
	Full Load	1/3	Light	Full Load	1/3	Light		Full Load	1/3	Light	Full Load	1/3	Light
AD 14	26770	30730	32700	4140	4690	4970	AOE 1	36650	48180	54600	6400	8000	8850
AD 24	23890	27430	29190	3810	4340	4610	AOG 58	7350	8900	9700	1800	2070	2200
AD 37	48050	50870	52280	7590	7960	8140	AOG 77	6900	9250	10450	2000	2350	2550
AD 41	44080	45640	47870	6600	6920	7080	AOG 81	7800	10300	11550	2400	2950	3200
AE 21	18950	22300	24000	4150	4600	4870	AOR 1	29050	37550	41750	7250	8600	9250
AD 26	30750	34950	37000	6900	7500	7850	AOT 50	14350	21100	24450	3850	4750	5250
AF 58	20400	23700	25350	3750	4250	4500	AOT 149	17350	27300	32300	4400	5800	6500
AFS 1	28350	32450	34500	5750	6400	6700	AOT 165	15700	25650	30620	4300	5600	6300
AG 153	21400	23050	23900	4750	5000	5100	AOT 168	14050	24700	30050	5300	6800	7600
AG 164	18800	23670	26100	5200	5450	5650	AOT 181	15650	25850	30950	5650	7050	7770
AGDS 2	19650	20300	20650	4800	4900	4950	AOT 182	15800	28200	34400	5000	6650	7500
AGER 2	2800	3150	3350	830	890	920	AP 110	35050	38500	40200	5850	6300	6500
AGF 3	29970	31900	32870	6830	7160	7320	AP 122	27800	32900	34450	5050	5750	6100
AGM 8	16150	19600	21300	4150	4650	4850	AP 197	26450	29400	30900	5500	5950	6150
AGM 9	34500	34850	35000	5000	5250	5350	APL 2	10550	11450	11900	2200	2350	2450
AGM 19	29250	33650	35800	5200	5750	6050	AR 5	27080	30420	32090	5050	5530	5770
AGM 22	21200	22850	23700	3800	4050	4150	ARC 2	11300	14750	16450	2150	2600	2800
AGM 23	Former AG 154						ARC 3	16300	17800	18550	3600	3800	3900
AGOR 7	4750	5100	5300	1020	1090	1130	ARC 7						
AGOR 11	7900	8200	8350	2200	2250	2300	ARL 24	10550	11650	12200	1600	1750	1850
AGOR 16	9450	9800	10000	4220	4300	4350	ARS 8/38	5450	5800	6000	1650	1700	1750
AGOS 1							ARS 50	6480	6820	7100	2335	2404	6200
AGS 21	13900	16650	18000	4150	4550	4800	AS 11	27250	30450	32050	5500	5950	6200
AGS 26	9900	10350	10550	2600	2680	2720	AS 19	30050	32550	33850	5000	5300	5500
AGS 29	17100	17700	18000	3500	3600	3650	AS 31	36900	39900	41400	5550	6000	6200
AH 17	25540	27390	28320	4500	4770	4900	AS 33	36750	41150	41500	6600	6700	6750
AK 237	12400	17800	20750	2950	3750	4150	AS 36	43150	46850	48500	6550	7000	7200
AK 255	16700	22800	25840	5050	5900	6350	AS 39	43210	45480	46620	6810	7120	7270
AK 271	7180	8660	9340	2170	2490	2650	ASR 9	6050	6500	6750	1050	1100	1150
AK 277	16600	22200	24950	3950	4750	5150	ASR 21	8800	9300	9550	4400	4500	4550
AK 280	12100	16300	18400	2750	3350	3650	ATA 181	2670	2890	3000	780	840	870
AKR 7	23200	27300	29350	5000	5700	6050	ATF 76	4200	4650	4850	920	1010	1050
AKR 9	25050	30000	32500	5400	6200	6600	ATF 166						
AO 57	17050	24150	27700	3900	4900	5400	ATS 1	8150	9250	9800	2100	2200	2250
AO 51	22000	30900	35300	4900	5930	6480	AVM 1	26350	28050	28850	5850	6050	6150
AO 105	17650	28350	33700	3850	5150	6750	AVT 16	61150	64800	66700	9200	9700	9950
AO 143	21850	30850	35350	5050	6300	6900							
AO 177	27100	34630	37990	5670	6870	7530							

Notes:

1. Windage areas measured by planimeter from profile and maximum cross section indicated in booklet of general plans for waterlines corresponding to the indicated loading condition. 10% of full load area added to account for handrails and other minor appurtenances not traced by planimeter.
2. Displacements within the same class may vary. Full load windage areas calculated for the maximum displacement (deepest draft) of any vessel in the class, light windage areas for the minimum displacement (shallowest draft). The 1/3 condition is the ship with 1/3 fuel, stores, and cargo.

Table B-17. Windage Areas[1], Surface Combatants.

Class	Broadside Wind Area, ft^2			Frontal Wind Area, ft^2			Class	Broadside Wind Area, ft^2			Frontal Wind Area, ft^2		
	Full Load	1/3	Light	Full Load	1/3	Light		Full Load	1/3	Light	Full Load	1/3	Light
BB 61	36750	41250	43550	6850	7450	7750	DDG 37	19950	21200	21800	2650	2750	2850
CA 134	28850	31100	32250	3650	3900	4000	DDG 47	26700	28100	28850	5500	5650	5750
CG 10	38800	41650	43050	6500	6800	6950	DDG 993						
CG 16	20050	22500	23700	3400	3650	3800	FF 1037	9850	10450	10750	1800	1870	1900
CG 26	19850	21600	22500	3450	3650	3750	FF 1040	11950	12700	13050	2100	2200	2250
CG 47							FF 1052	14650	15700	16200	2800	2900	2950
CGN 9	36100	36900	37350	7200	7250	7300	FF 1098	11500	12150	12500	1900	1980	2020
CGN 25	20900	21350	21550	3230	3280	3300	FFG 1	12500	13200	13600	2100	2200	2250
CGN 35	22500	22900	23150	3290	3340	3360	FFG 7	15290	15730	15970	2200	2230	2240
CGN 36	26050	27000	27450	3700	3800	3850	LCC 19	34350	36280	37250	6950	7220	7360
CGN 38	23900	24800	25200	4340	4430	4480	LHA 1	71250	74950	76750	10750	11250	11500
CV 34	59350	63200	65150	8300	8800	9050	LHD 1						
CV 41	64550	69150	71400	8700	9350	9650	LKA 112	25650	29100	30800	4600	5050	5300
CV 59	73850	79100	81750	13500	14200	14550	LKA 113	30100	33550	32250	6850	7400	7650
CV 63	79500	85050	87850	13900	14650	15000	LPA 249	29150	32150	33650	5200	5600	5800
CV 67	75250	80500	83100	15650	16350	16700	LPD 1	27600	29800	30850	7750	8100	8300
CVA 31	59350	63200	65150	8300	8800	9050	LPD 4	31100	34000	35450	7700	8100	8350
CVN 65	79000	83050	85050	16950	17450	17750	LPH 2	36920	40260	41920	5970	6480	6730
CVN 68	79450	84150	86550	14750	15350	15650	LSD 28	21150	23350	24400	5600	5950	6150
CVS 11	59700	63500	65400	11950	12450	12650	LSD 36	29150	31350	32400	6950	7300	7450
DD 743	8800	9650	10100	1250	1350	1400	LST 963	10550	11650	12200	1600	1750	1850
DD 931	11750	12750	13200	1850	1950	2000	LST 1173	15750	17300	18050	2700	2900	3050
DD 937	13050	13950	14450	2100	2200	2250	LST 1179	22950	24650	25450	4800	5050	5200
DD 963	24100	25250	25850	4250	4350	4400	MCM 1						
DDG 2	14750	15900	16450	2900	3000	3100	MSO 427	4100	4400	4550	1250	1310	1340
DDG 31	14450	15400	15850	2120	2220	2270	PG 92	2860	3000	3070	610	630	640
							PHM 1	2320	2400	2440	900	920	930

Notes: See Table B-16

Table B-18. Windage Areas[1], Submarines.

Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²			Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²		
	Full Load	1/3	Light	Full Load	1/3	Light		Full Load	1/3	Light	Full Load	1/3	Light
AGSS 555	1010	1130	1190	60	66	70	SSN 575	4490	4920	5130	280	310	320
AGSS 569	1710	2160	2380	220	290	320	SSN 578	2170	2420	2540	200	220	230
NR 1	490	570	600	55	60	65	SSN 585	1960	2250	2390	250	280	300
SS 565	3800	4180	4380	290	320	340	SSN 586	6940	7380	7580	680	720	730
SS 574	4350	4800	5020	410	450	470	SSN 587	4740	5210	5440	380	410	430
SS 576	3540	3900	4080	290	320	340	SSN 588	2100	2360	2490	240	270	290
SS 580	2060	2540	2780	310	340	350	SSN 594	1770	2080	2240	180	210	230
SSAG 567	3800	4180	4380	290	320	340	SSN 597	2050	3010	3490	110	180	220
SSBN 598	2990	3830	4250	400	460	490	SSN 637	2580	3090	3340	200	250	270
SSBN 608	3810	4560	4940	360	410	440	SSN 671	2000	2410	2610	190	230	250
SSBN 616	4040	4870	5280	380	430	460	SSN 685	2480	2870	3060	210	240	260
SSBN 726	6070	7860	8760	450	570	630	SSN 688	2800	4120	4780	220	330	390
SSN 571	3290	3850	4130	310	350	370							

Notes: See Table B-16

Table B-19. Windage Areas[1], Service Craft.

Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²			Class	Broadside Wind Area, ft²			Frontal Wind Area, ft²		
	Full Load	1/3	Light	Full Load	1/3	Light		Full Load	1/3	Light	Full Load	1/3	Light
YAG 61	3460	3900	4120	840	920	970	YOG 58	2520	3380	3820	610	780	860
YC 1469	740	1090	1260	220	330	390	YP 654	1160			290		
YDT 14	1880	1970	2010	570	590	600	YPD 32	2350	2420	2460	1890	1920	1940
YFB 87	2920			1460			YR 24	3700	3870	3950	880	920	940
YFNB 4	5260	6370	6930	830	1040	1140	YRBM 1	3240	3300	3330	970	990	1000
YFND 5	1580	1860	2000	480	580	620	YSR 30	1300	1650	1820	390	520	590
YFRT 287	1820	2140	2300	610	680	720	YTB 752	1790			560		
YFU 71	1530			740			YTM 146	2630			860		
YO 47	3730	5000	5630	1070	1270	1380	YW 83	2520	3380	3820	610	780	860
YO 106	2520	3380	3820	610	780	860							

Notes: See Table B-16

Table B-20. Windage Areas[1], Floating Drydocks.

Class	Broadside Wind Area, ft²		Frontal Wind Area, ft²		Class	Broadside Wind Area, ft²		Frontal Wind Area, ft²	
	Maximum Submergence	Light	Maximum Submergence	Light		Maximum Submergence	Light	Maximum Submergence	Light
AFDB 1	4700	32800	2200	9500	AFDM 1,2	4000	28000	1300	3200
AFDB 2	8400	65900	2200	9500	AFDM 3,5-10	5000	30000	1400	3600
AFDB 3	7800	59600	2200	9500	ARD 5,7,8	430	17500	1750	3700
AFDB 4, 5	7300	49800	1900	7200	ARD 12,30,32; ARDM 1,2	5400	18600	2000	4400
AFDB 7	4200	28500	1900	7200	ARDM 3	5140	23050	2570	5340
AFDL 1,2,6,8-12, 15, 16,19,21,23,25,29	800	4600	150	800	ARDM 4	2800	24200	210	2500
AFDL 7,22,23	1200	7800	300	1000	YFD 8	3300	28000	100	2600
AFDL 37,38,40, 41,44,45	2000	10700	900	1900	YFD 23	1900	19800	70	1800
AFDL 47	4000	18600	900	2500	YFD 54	2000	13000	200	1300
AFDL 48	3100	14200	830	1560	YFD 68-71	2900	25600	250	2450
					YFD 83	800	4600	150	800

Notes: See Table B-16

B-6 COMMERCIAL VESSEL DESCRIPTIONS

Both naval and commercial vessels are broadly grouped by service, e,g., destroyer, general cargo, bulk carrier, tanker, tug, etc. Characteristics can vary widely between ships or classes within a broad grouping or type, but the requirements of similar service dictate similarities in construction, hull form, and outfit. Familiarity with the general characteristics of different ship types helps the salvage engineer perform four critical functions:

- Rapidly analyze the casualty's condition and overall salvage situation; because of differences in construction and stability parameters, identical conditions may be more dangerous or entail a more difficult salvage for one type of vessel over another.
- Tailor surveys to examine typical vessel characteristics that may be particularly important in light of the casualty condition, or that may hinder or facilitate salvage work.
- Evaluate whether calculated hydrostatic, stability, or strength parameters are reasonable for the type of vessel; this is particularly important when calculations must be based on limited data.
- Evaluate whether empirical relationships valid for vessels of "ordinary form" can be applied to a specific casualty with reasonable accuracy.

The following paragraphs describe some of the important ship types afloat today. These descriptions provide a range of parameters and characteristics for each type and do not necessarily apply to any specific vessel. Dimensions, proportions, weights, and other characteristics of an assortment of commercial vessels are given in tables at the end of the narrative descriptions.

B-6.1 General. Most seafaring nations have established classification societies which review standards for the construction of merchant vessels. Classification societies publish construction guidelines and stability and operating standards to ensure vessel safety and standardization of ship construction and other marine equipment. Most also publish registers of classed ships giving basic characteristics and capacities (see Paragraph B-2.1.9).

The International Maritime Organization (IMO) of the United Nations, which evolved from the Intergovernmental Maritime Consultative Organization (IMCO), develops standards concerning the safety of life at sea, including restrictions on individual cargo tank size, subdivision and stability, guidelines for chemical carriers, and concepts designed to limit pollution of the sea in a casualty. The work of the IMCO, and subsequently the IMO, has also played a role in the standardization of ship and marine structure design. IMO and classification standards are often adopted by regulatory bodies of various nations. Standards and registers can be important sources of information to the salvor.

Certain basic design concepts are common to all merchant ships as well as cargo carrying naval auxiliaries. The nature of merchant vessels is such that a high proportion of hull volume is devoted to cargo space in the form of holds or tanks. All merchant ships have systems designed to maintain cargo, fuel, and liquids. Work and accommodation spaces are isolated from cargo areas. Virtually all cargo ships built today have their machinery spaces aft of most or all the cargo spaces. Many cargo carriers have cabin accommodation for up to 12 passengers (most countries of registry require a special certification to carry more than 12 passengers). Most have diesel or steam turbine propulsion and auxiliary power.

Naval auxiliaries differ from similar merchant vessels because of the requirements imposed by their service. Deadweight and cargo capacity for Naval auxiliaries is reduced by space and weight allocated to:

- Typically larger crew sizes, with attendant increases in the requirements for accommodation spaces and outfit, and lifesaving equipment.
- Weapons systems and their required magazines, including local strengthening.
- Special outfit, equipment, and construction details to meet Navy damage control and nuclear-chemical-biological warfare requirements.
- Special mission required equipment, such as replenishment rigs for fleet oilers, including required local strengthening.
- Larger communications suites.
- Larger auxiliary machinery plants to support the requirements imposed by some of the above items.

Merchant ships, in the broadest sense, can be classified as either *liners* or *tramps*. Liners sail on a definite route for specific destinations, with set dates of arrival and departure at various ports. Tramps are cargo vessels whose voyages are dictated by the availability of suitable cargoes and destinations, rather than by fixed route or schedule. The term liner includes cargo ships, ocean-going passenger ships, and cross-channel ships typified by faster service speeds and finer lines than tramps.

The term "Panamax" refers to design size limitations imposed by the Panama Canal locks and adopted by the international shipping community: beam must not exceed 106 feet (32.2 m), fully loaded vessels must not exceed 80,000 tons deadweight. Ships designed for service on river and canal systems may be similarly constrained by canal and lock dimensions.

B-6.1.1 Cargo. Cargo stowage and handling requirements are a major influence on ship design. Cargo requirements may also impact salvage operations directly. There are three basic cargo classifications:

- Bulk Cargo
- General or "Breakbulk" Cargo
- Unitized Cargo

Bulk cargo consists of homogeneous materials in liquid, gaseous, or solid form with relatively small particle size. General cargo includes a myriad of products packaged or un-packaged with unit size ranging from man-carriable bags and boxes to railroad locomotives. Some examples include bagged agricultural or mineral products, boxed and crated manufactured goods, liquids in cans, drums, and barrels, bundled or single pipes, logs, steel shapes, lumber, etc., and large single items such as aircraft or automobiles. Unitized cargo is shipped in containers with standard dimensions that may be carried by specialized or nonspecialized ships. Standard shipping units include pallets, intermodal containers in various sizes, several standard lighters for carriage by barge carrying ships, and motor vehicle trailers. A wide variety of bulk and breakbulk cargo, including mail, machine parts, partially assembled aircraft, motor vehicles, refrigerated foodstuffs, and some liquids are transported as unitized cargo, primarily in intermodal containers. Many ships designed to carry other types of cargo have some space and gear devoted to the handling and stowage of containers or other unitized cargo.

In addition to these categories, some types of cargo may exhibit qualities of both bulk and general cargo, such as baled goods or vehicles shipped in sufficient quantity to fill an entire hold or vessel.

B-6.1.2 Tanks. All ships have fuel tanks, ballast tanks, fresh water tanks, and smaller tanks for lube oil, fuel oil settling and other specific purposes. Shifting liquids in or out of these tanks is a standard salvage practice for altering stability, affecting ground reaction in stranding's, or altering longitudinal bending moments. Tank size, location, and contents are of prime interest to salvors when making a weight analysis. Fuel tanks, ballast tanks, and cargo spaces usually represent the best potential weight transfer alternatives because of their large size and dedicated piping systems.

Cargo pumps are usually located in dedicated pump rooms, which may also function as cofferdams separating cargo tanks from living or working spaces. Most cargo pumping systems include tank discharge and stripping systems. Most tankers employ gas inerting systems to reduce explosive hazards in tanks. Ballast and fuel pumps are usually located in and operated from the main machinery spaces. Some general observations can be made concerning typical tankage arrangements:

- Tank centers of volume are usually low in the ship so that the weight of the contents contribute to overall ship stability.
- The transverse dimensions of most tanks are restricted in order to limit free surface effect.
- Limited access (for cleaning, inspection, and maintenance) to tanks low in the ship is provided by manholes.
- Tanks are usually located symmetrically with respect to the centerline; port and starboard tanks are often cross-connected.
- All tanks are equipped with vent lines to the weather decks and ullage openings or sounding tubes for gauging contents.

B-6.1.3 Cargo-handling Systems. Typical cargo-handling gear is addressed under particular ship type headings, but some general arrangements can be noted here. General cargo ships are typically fitted with derricks or deck cranes to load or discharge cargo from piers or lighters without assistance. Most tankers discharge cargo with installed pumps and generally carry sufficient cargo hose to connect to receiving terminals; many tankers have small derricks or cranes to handle the cargo hose.

Many ship types are *gearless*, that is, they are not fitted with cargo gear. Modern container ships rarely have the ability to handle their own containers and can load and discharge cargo only with the aid of specialized port facilities. If installed, container ship cargo gear may consist of conventional derricks or rotating cranes, or traveling overhead gantry cranes. Most bulk carriers are gearless although there are some *self-unloaders* with installed derrick grabs or conveyor systems for discharging cargo, particularly on the Great Lakes. Roll-on/roll-off (RO/RO) ships load cargo over ramps through stern, bow, or side ports; in the case of trailers, vehicles, and train cars, part of the cargo gear is integral to the cargo itself.

When installed and operable, a vessel's cargo gear can be a great asset to the salvage effort. Lightering is most effective and efficient when accomplished with ship's gear. The large number of derricks or cranes on general cargo ships facilitates loading salvage equipment and placing it in its required location on deck or in holds. Deck mounted gantry cranes are particularly useful for shifting weight longitudinally to adjust trim, weight distribution, or ground reaction; the cranes themselves are large weights that can be shifted.

B-6.2 General Cargo Ship. Modern cargo vessels evolved from the classic *Liberty Ship*, the prototype of which first appeared in the late1800's. Because the simple design was well suited to mass production, many Liberty Ships were built during World War II to support Allied shipping requirements. Liberty ship designs featured machinery spaces and superstructure amidships, as shown in Figure B-8.

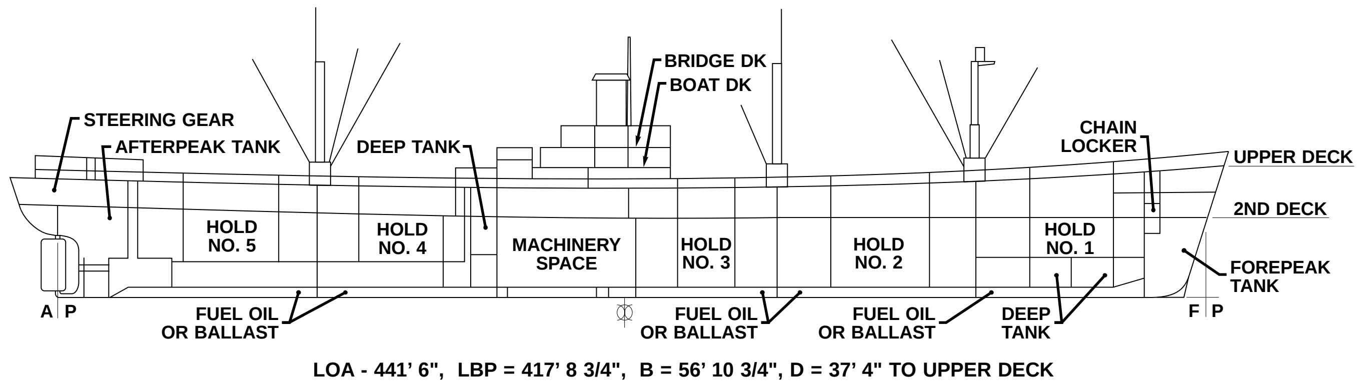


Figure B-8. Liberty Ship (MARAD Type EC2).

Modern dry cargo ship designs maximize hold space, as shown in Figure B-9. A typical mid-size ship may have five or six holds; three or four forward of the machinery space and superstructure, and one or two aft. The machinery spaces and superstructure are usually located about three-quarters aft. Older designs typically have three holds forward of the superstructure and two aft. Holds aft of the accommodation and machinery spaces improve the trim of the vessel when partially loaded, and provide the ship with sufficient draft aft for stability and propeller immersion. Small freighters often have machinery and accommodation spaces aft of all cargo holds. Deadweight of modern general cargo liners ranges from 9,000 to 25,000 tons; speeds range from 17 to 22 knots. Tramps are typically smaller and slower, with speeds ranging from 12 to 18 knots. The speed-to-length ratio is generally 0.87 or less as higher ratios are usually not economical. Laden drafts are as deep as channels to the intended terminal ports allow, typically in the 26- to 29-foot range. Hull depth is selected to provide the desired draft and satisfy statutory freeboard requirements. Depth of the double bottom is kept low to maximize cargo space. Tables B-21, B-31, B-32, and B-33 (Page B-31 and Pages B-51 through B-53) provide characteristics of a typical general cargo ship.

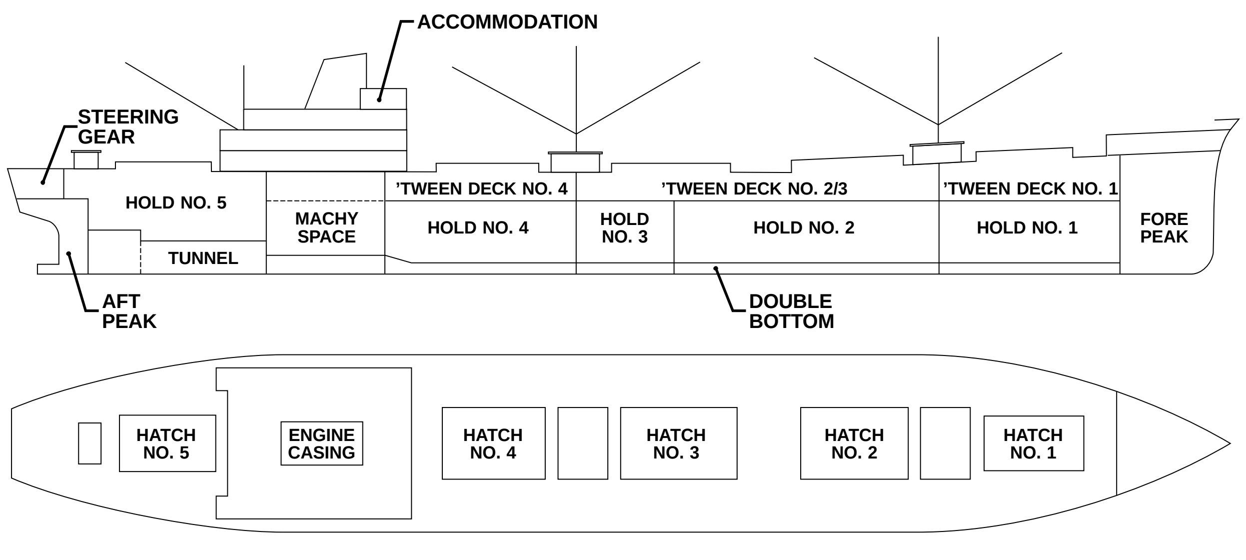


Figure B-9. General Cargo Ship.

Watertight bulkheads separate individual holds, machinery spaces, and tanks. One or more 'tween decks may be fitted to facilitate flexibility in cargo loading and unloading, cargo segregation, and to improve stability. There may be watertight doors in the bulkheads on the 'tween decks levels. Denser cargoes are carried in the lower holds with high stowage factor products normally stowed in the 'tween decks. Refrigerated spaces may be built into the 'tween decks. Tramps are designed to carry a wide variety of commodities while liners may be designed for a specific trade. Ship designs for a specific trade strive for "full and down" operation; the ship's freeboard is down to her loadline with cargo cubic fully occupied. For a given trade, hold spaces are usually designed so that the ratio of bale cubic to deadweight is 10 to 15 percent greater than the overall stowage factor of the goods carried to allow for more rapid cargo handling and *broken stowage* – the spaces between and around cargo units, including dunnage, and spaces not available for cargo stowage because of physical obstructions or ventilation and access requirements. Holds are sized and provided with cargo gear to limit the amount of cargo cubic per stevedore gang to about 60,000 cubic feet; holds in the midbody are therefore usually shorter than those nearer the ends of the ship. The conflict between the desire to shorten holds and the length required by cargo gear and hatches sometimes dictates the assignment of midships spaces to machinery or to fuel, cargo, or ballast deep tanks rather than holds.

Hatches are as large as possible without compromising hull strength (the main or second deck is normally the strength deck) to reduce the requirement for horizontal movement of cargo within the holds. Hatches served by two sets of cargo gear generally measure 20 by 30 feet or larger. Hatches on older ships are generally smaller than those on newer ships. Hatches are surrounded by coamings to reduce the risk of flooding in heavy seas. Covers are usually constructed of steel (or wood on older vessels). The main deck plating between hatches is not effective in providing longitudinal strength, and is sized to carry fairly light local loads. The deck plating outboard the hatches is therefore much heavier, often exceeding five-eighths inch in thickness.

Table B-21. Typical General Cargo Ship.

Dimensions (ft)	
Length overall	579
Beam	82
Depth to main deck	46
Design Draft	27
Speed and Power	
Design sea speed, knots	22
Shaft horsepower, approx.	20,000
Deadweight and Displacement (long tons at scantling draft)	
Light ship	9,790
Total deadweight	14,250
Cargo deadweight	12,000
Full load displacement	24,040
Capacities	
General cargo, bale, ft^3	775,000
Refrigerated cargo, net, ft^3	40,000
Cargo oil, tons at 40 ft^3/ton	1,000
Dry bulk cargo (grain), ft^3	311,000
Total containers ($8 \times 8 \times 20$ ft)	216
2-high on deck	96
Below deck	120

Cargo gear is designed for speed and flexibility for handling breakbulk, palletized, or container cargo. Various combinations of derricks, winches, and deck cranes are used for the handling of cargo. Cranes are fitted on many vessels to reduce manpower requirements. Some ships have special heavy-lift derricks that may serve one or more holds. Booms are rigged for either yard and stay (burton) or swinging-boom operation.

Virtually all general cargo ships use double-bottom spaces as fuel and ballast tanks. More recent designs assign several tanks exclusively to segregated saltwater ballast. Some vessels have built-in systems for handling oil cargoes in double bottom or deep tanks, and for cleaning and heating the tanks. In many designs, several holds can be specially fitted for carrying grains or other dry bulk cargos. Grain feeders may be built in and used for access trunks. Other grain fittings commonly fitted include deck and bulkhead cuts (trunk bulkheads) fitted with gratings.

B-6.3 Combination Cargo-Passenger Ship. Cargo-passenger ships are essentially general cargo ships with increased accommodations for passengers. Most are designed to handle most commodities and typically operate to and from tropical ports in third world countries. They are often rigged primarily to transport agricultural products and tropical fruits on one voyage leg, and finished industrial products on the reverse leg. Typical cargoes include motor vehicles, general cargo suitable for containers and pallets, bulk liquids (lube oil, detergents, molasses, etc.), fruit, frozen shrimp, bagged coffee and cocoa beans, balsa wood, etc. Table B-31 gives general characteristics for a typical cargo-passenger ship.

Cargo-passenger ship holds often include cellular-type container stowage for twenty- and/or forty-foot intermodal containers. A typical arrangement can accommodate up to 175 twenty-foot containers, or mixed loads with up to 44 forty-foot containers and 87 twenty-foot containers, handled by travelling gantry cranes. In addition to containers, the gantry cranes are designed to handle automobiles, trucks, pallets, and rough cargo through main deck hatches. Designs emphasize flexibility in handling varying amounts of breakbulk and containerized cargo and often incorporate vertical and horizontal conveyor systems for handling bananas and other fruit.

B-6.4 Refrigerated Cargo Ships. Refrigerated cargo ships are basically fast general cargo ships with extensive refrigerated spaces for the transport of meat, fruit, and dairy products. They may several 'tween decks. Cargo may be carried frozen or chilled. Hold volume is less than an equivalent sized cargo ship because of the space taken by insulation—about 25 percent less for chilled cargo and about 35 percent less for frozen cargo. If all cargo spaces are refrigerated, the ship is called a *fully refrigerated ship*, or *reefer*. If only some of the holds are refrigerated, the ship is a *partial reefer*; the refrigerated holds are generally those closest to the machinery spaces.

Cargo volume is an important factor since refrigerated cargo has a fairly high stowage rate: chilled beef stows at about 127 cubic feet per ton, frozen beef at about 94 cubic feet, and bananas at about 157 cubic feet. Chilled beef is hung from hooks and chains, with approximately one foot clearance between the meat and the deck for air circulation; the effective *KG* of the hung meat is thus at the overhead of the storeroom, rather than near mid-height. Frozen meat is usually stacked; storage height is usually less than 20 feet to avoid crushing the lower tiers. Cargo spaces may be divided into bins for the stowage of fruit; permanent uprights, slotted to accept removable battens, are fitted at about 10 foot intervals.

B-6.5 All Hatch Ship. To reduce the requirement for horizontal movement of cargo in holds or 'tween decks spaces, many general cargo ships are designed with very wide hatches, sometimes extending for as much as four-fifths the width of the deck. Two or three hatches abreast are sometimes fitted, rather than a single wide hatch. A typical *three-hatch* design is shown in Figure B-10. Because the small deck area does not provide sufficient resistance to racking, heavy web or cantilever frames are fitted at frequent intervals, along with heavy hatch-end beams. Deep hatch coamings on the upper deck tie the frames together and provide transverse rigidity. Longitudinal strength is achieved by heavy sheer strakes and side deck stringers, often with heavy longitudinal girders. The deep hatch coamings are often made continuous throughout the length of the cargo deck. In multi-hatch designs heavy deck plating and girders between hatches provide part of the ship's longitudinal strength. In some designs the deck between hatches is supported by longitudinal bulkheads rather than stanchions. The resulting segregated cargo space is well suited to carrying diverse cargoes that may require separation, and limiting athwartships shifting of bulk granular materials. All-hatch ships are sometimes converted to container ships by fitting temporary or permanent cell guides in the holds.

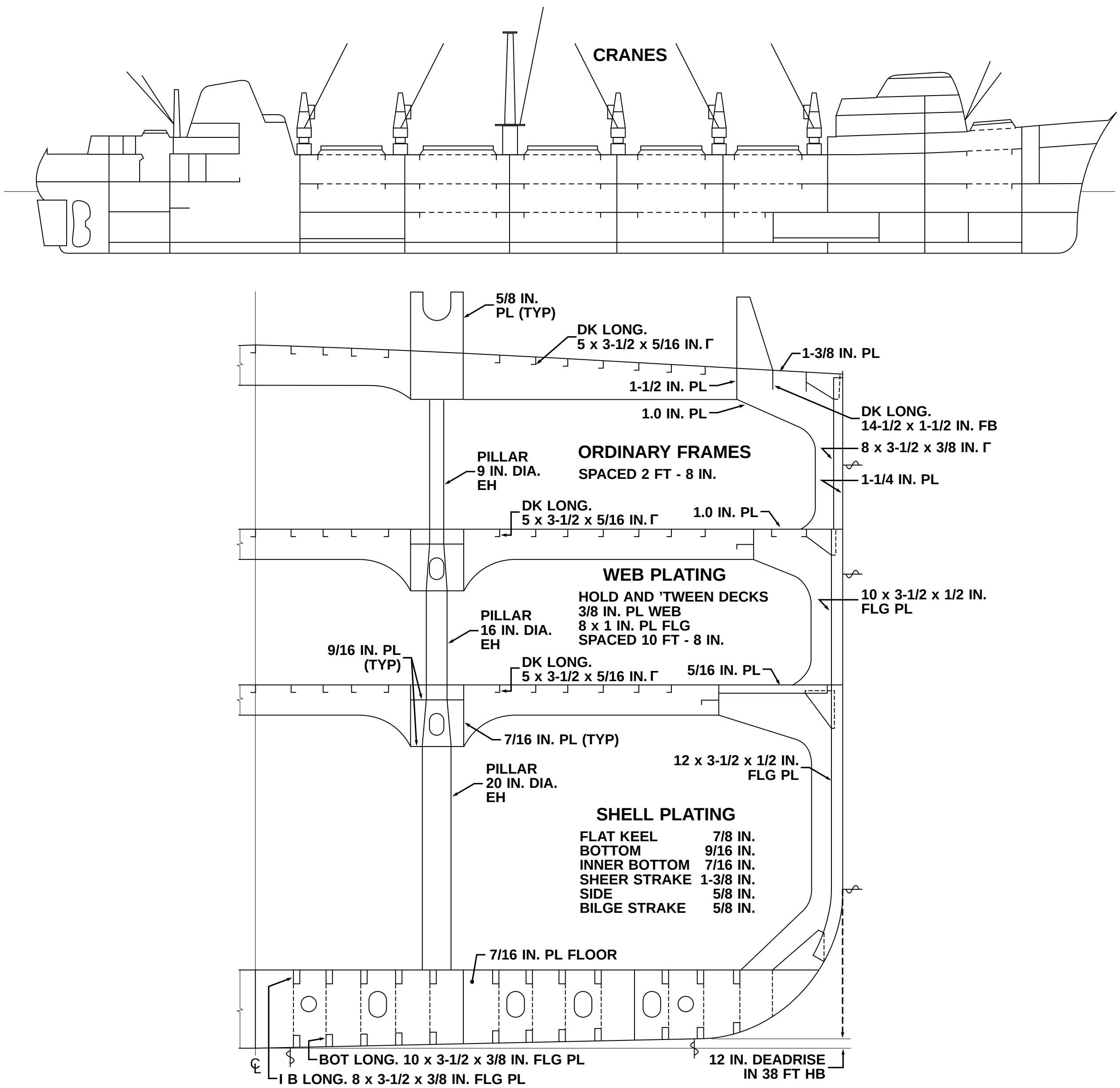


Figure B-10. Three-Hatch Ship.

The ships bridge is typically situated well forward and separated from the after deck house. Most of the cargo spaces lie between the bridge and the aft machinery space. Table B-22 gives general characteristics of a typical three-hatch design.

Table B-22. Characteristics of a Typical Three-Hatch Ship.

Dimensions (ft)		
	Length overall	506-2
	Length between perpendiculars	482-0
	Beam	70-0
	Depth to main deck	45-0
	Design draft	28-0
Speed and Power		
	Design sea speed, knots	18
	Shaft horsepower, approx.	11,660
Deadweight and Displacement (long tons at design draft)		
	Total deadweight	10,976
	Displacement	16,820
Cargo Capacities		
	General cargo (cu ft)	657,213
	Refrigerated cargo (cu ft)	22,433
	Liquid cargo (tons)	1,890

B-6.6 Container ships. Before 1960, the specialized container ship was virtually unknown as a ship type. Since then there has been a rapid development of larger and faster vessels of this type. Most modern container ships are of the vertical cell type, although there is also a horizontal loading type. Container ships load and unload much faster than general cargo ships, but are not normally fitted with cargo gear. Because of this, container ships trade primarily through developed ports with appropriate terminal facilities. In addition to *fully containerized ships*, four other classes of ships handle containers:

- *Partial container ships* with a major portion of the cargo spaces designed for the stowage and handling of containers with the remaining capacity devoted to other forms of cargo, often loaded by roll-on/roll off means.

- *Convertible container ships* with special arrangements and outfit that enable all or part of the vessels capacity to be converted for container stowage with the remaining capacity used for general or bulk cargo.

- *Ships of limited container capacity* that are primarily designed to carry other forms of cargo but have some container handling and securing devices.

- *Ships without special container stowage arrangements* on which containers are handled as oversize cargo and secured on deck or in holds by traditional means.

Ships designed to carry containers on deck are normally arranged to keep the upper deck as dry as possible, by use of high freeboard, flaring bows, or placing the deck house forward of deck container stowage.

B-6.6.1 Containers. Intermodal dry cargo containers are essentially reinforced rectangular boxes. A typical container is shown in Figure B-11. The American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) have developed standards for dimensions, strength, and fittings for intermodal freight containers. Standard dry cargo containers are 8 feet wide, 20, 30, or 40 feet long, and 8, 8½ or 9 feet high. With special fittings, shorter containers can be loaded in standard container cells; nonstandard containers with lengths of 6 feet 8 inches and 10 feet are therefore fairly common, as well as 24-, 35- and 45-foot containers. Containers less than 30 feet long often have forklift pockets, longer containers usually do not. Containers are steel framed with sides, overhead, ends of corrugated steel, steel faced plywood (plymetal), aluminum, or fiberglass reinforced plywood (FRP). Floors may be hard or softwood laminate, planking, or plywood; the interior may be lined with plywood or battens. Cross members supporting the floor or top may be box, C-, Z-, or I-beams welded or bolted to the side rails. The end frames are fitted with standard handling and securing corner fittings, usually steel castings that are welded to the corner posts. Doors extending the width of the container and consisting of flat panels fitted with locking hardware and weatherproof seals are fitted at one end. Containers must meet minimum strength requirements to ensure that loaded containers can be stacked six high for storage or transport. In addition to the common box-type container, a number of special containers have been developed, including half-height containers, open top and hopper containers for carrying bulk granular materials, various types of tanks enclosed in frames meeting container dimensions, and open frames for carrying vehicles. Dry cargo container capacities are given in Table 9-7.

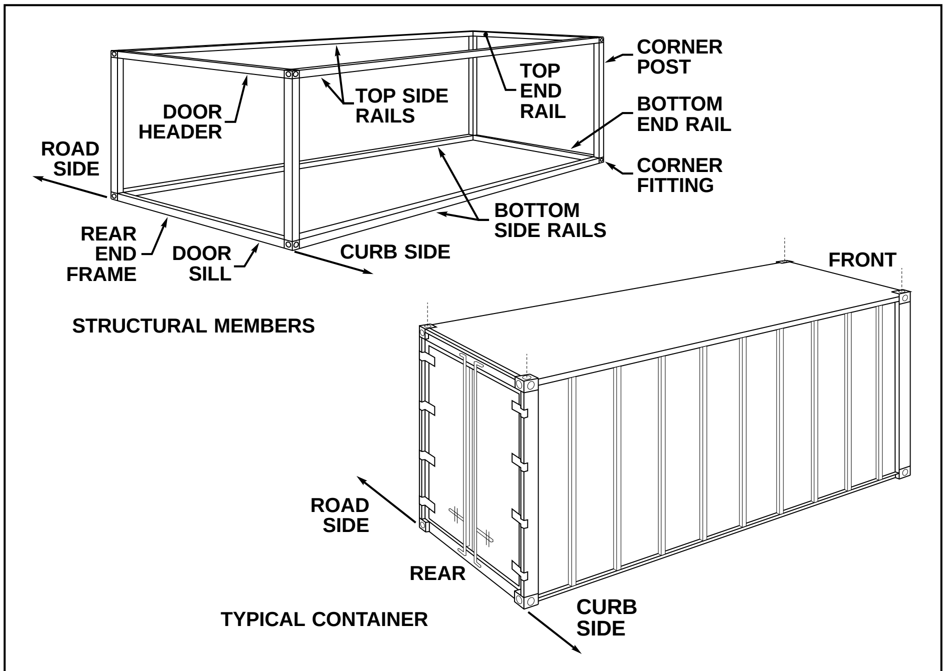


Figure B-11. Intermodal Container.

Cargo capacity for container ships is frequently expressed in terms of 20 or 40 foot equivalent units (TEU or FEU) i.e., the number of containers that could be carried if all were standard 20- or 40-foot containers. Although a recent development, the current trend is to adopt forty foot containers and the FEU as the industry standard.

B-6.6.2 Vertical Cell Container Ships. Vertical cell container ships carry containers stacked in cells formed by angle corner guides. The containers are lowered into and lifted from the cells by gantry cranes on the pier, or more rarely, on the ship. Cargo spaces are arranged to give maximum container capacity within the minimum hull volume, with due allowance for structure, clearances, and hydrodynamic requirements for the hull form. Many container ship designs also include significant stowage space for general, dry bulk, and liquid cargo. Vertical cell container ships and cell construction are illustrated in Figure B-12 (Page B-35). Tables B-23, B-31 (Page B-51), B-32 (Page B-52), and B-34 (Pages B-54 and B-55) give characteristics of typical cellular container ships.

Table B-23. Typical Vertical Cell Container Ship Characteristics

Dimensions (ft)	
Length overall, approx.	585-0
Length between perpendiculars	530-0
Beam	79-0
Depth to main deck	40-0
Design draft	28-6
Speed and Power	
Service speed, knots	20.5
Shaft horsepower, approx.	18,500
Deadweight and Displacement (long tons at design draft)	
Light ship weight	9,650
Total deadweight	9,900
Cargo deadweight	7,100
Displacement	19,550
Cargo Capacity	
Containers ($8 \times 8 \times 20$)	
Dry cargo	458*****/ 490,000 ft^3
Refrigerated Cargo	22 / 19,000 ft^3
Total	480 / 509,000 ft^3
General cargo (bale)	93,000 ft^3
Dry Bulk (bale)	90,000 ft^3
Liquid Bulk (net)	25,000 ft^3

* Including 70 on deck

Container cells are arranged in athwartships groups with the long axis of the containers fore and aft. The transverse width of the cell groups may be 80 percent of the ships breadth, requiring large hatches. The container cells consist of corner guide angles attached to the ship structure. The guides are installed to fit the standard containers with fairly tight clearance to limit container movement while underway. Because of the small clearance between container and guide, containers can be loaded or discharged without binding only with the ship within very narrow limits of list and trim. Containers are secured to each other in the cell racks by special pins and then lashed to the deck with wire and chain. The weight of the stacked containers is normally transmitted directly to the inner bottom, with the cell guide structure carrying only horizontal forces resulting from ship motions, list, and trim. If containers are stacked more than six high, movable supports on the vertical structure support the upper containers. Hatch covers are normally of the lift-off pontoon type, with hydraulic or manual dogs. Because the covers are normally handled by a gantry crane, they are usually large and span the length of one cell and the width of several cells. Most cell-type container ships are designed to carry a large number of containers on deck, in single tiers or stacked on the hatch covers. The containers are secured by locking the lower corners to the deck or hatch covers by special fittings, tieing the upper corners together transversely, and with special diagonal lashings secured to fittings at the ends of the rows. Refrigerated containers are normally carried on deck, where ventilation required for the built-in electric powered refrigeration units is provided naturally. Electric connection boxes are installed at designated locations. Containers with hazardous cargo are usually carried on deck or at the top of a stack in a hold.

The number of cell groups within a hold or bay is dictated by the requirements of structure and watertight subdivision. Transverse watertight bulkheads between holds extend to the main deck, making it the bulkhead deck. A container ships longitudinal structure consists essentially of bottom and shell without decks, longitudinal bulkheads, or stanchions. Heavy floors with web frames are fitted at intervals in the wings outboard the cell groups, or extending between cell groups in some designs, to give transverse rigidity. The inner bottom longitudinals, bilge strakes, sheer strake, and the narrow main plating outboard the cell groups are quite heavy to provide the necessary longitudinal strength. The upper portions of the wings often form a large, heavy box girder, as shown in Figure B-12 (Page B-35). The requirement for minimum interference with cargo stowage leads to common use of higher strength steels, particularly in the upper deck.

Capacity (TEU or FEU) and speed distinguish different "generations" of container ships. Most container ships built before 1968 (1st generation) have capacities of 500 to 700 TEU, with service speeds of less than 22 knots. Many first-generation container ships were converted from general cargo ships or bulk carriers by the installation of container cells. Most second-generation ships, built between 1968 and 1972, have capacities of 1,200 to 1,500 TEU, with about 40 percent of the containers carried on deck and service speeds of 22 to 26 knots. Third-generation ships, built since 1972, have capacities of up to 1,800 to 2,200 TEU (60,000 tons deadweight). Service speed may be 26 knots or more.

For salvage operations, lightening the ship can be problematic and tedious because containers may jam in their cell guides if the casualty has significant list or trim, and because the containers with the heaviest loads are often stowed near at the bottom of stacks near the centerline, under many lighter or empty containers. Because tankage is often limited to double bottom ballast tanks, relatively small bulk cargo tanks in some designs, and to fore and after peak tanks, selective ballasting to alter conditions may be difficult or impossible.

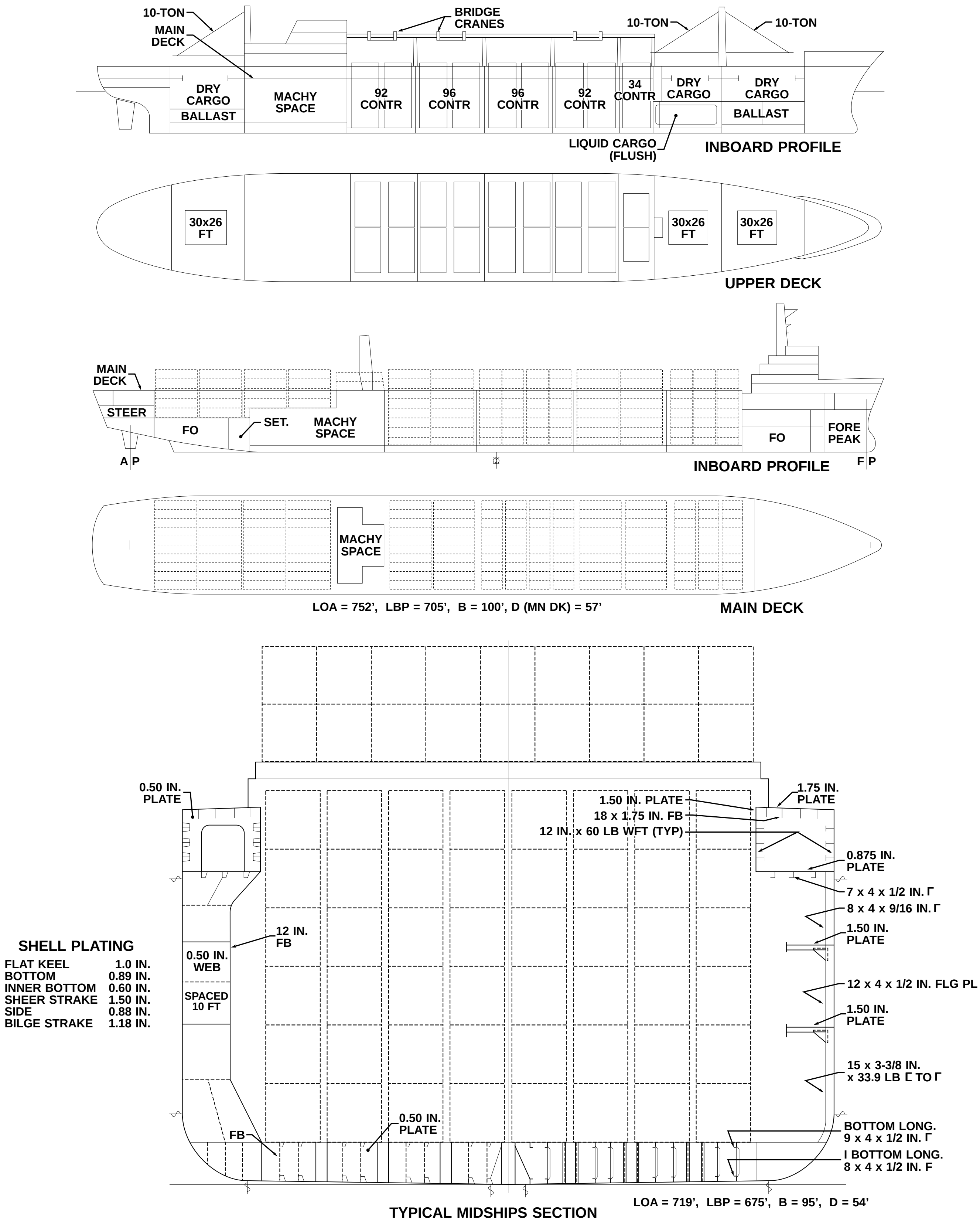


Figure B-12. Vertical Cell Container Ships.

B-6.6.3 Horizontal Loading Container Ships. Horizontal loading container ships are less common than vertical cell container ships, and less distinct as a ship type. Containers are loaded through stern or side ports by fork lifts or straddle trucks, usually onto a single container deck that extends for most of the length of the ship. In this respect, they may be considered a type of roll-on/roll-off ship, with which they share a number of features. Containers are normally stowed with the long axis athwartships to suit the fore and aft travel of the forklift. Access to groups of containers can be attained by leaving aisles empty. Although usually designed for a specific container size, the ship can readily load cargo that meets under deck clearances and is adaptable to handling by fork lift or other rolling equipment: different sized containers, palletized cargo, vehicles, trailers, etc. The ship may carry its own forklifts.

Beam is selected to equal an even multiple of container length, plus requirements for side framing, stanchions, and clearances. The container deck is free of transverse bulkheads and the number of stanchions is kept to a minimum to enhance fork lift maneuvering and flexibility in cargo stowage. Screen bulkheads with large sliding or accordion type doors are fitted at intervals to contain carbon-dioxide or other firefighting gases. The ships are designed with minimum freeboard, as the container deck is the bulkhead deck. A main structural feature is the strength of the container deck which must carry the concentrated loads of the container corners and wheels of lift trucks bearing loaded containers. Spaces below the container deck are allocated to machinery, fuel, ballast tanks, liquid cargo, and occasionally special cargo handled by rapid methods (such as refrigerated cargo handled by conveyor). The weather deck is not normally designed for loading of containers by lift truck because of the heavy structure that would be required, and the difficulties in carrying containers up ramps. The weather deck may be designed for carrying automobiles loaded by ramp, or light containers and similar bulky cargo loaded by overhead lift gear.

B-6.7 Roll-On/Roll-Off Ships. The roll-on/roll-off (RO/RO) ship employs the unitized cargo concept, but preceded the purpose-built containership by nearly a decade. The designation RO/RO covers a broad category of ships designed to load and discharge cargo that can be loaded as or by rolling stock. Broadly interpreted, this includes trailer ships, vehicle carriers, train ships, and passenger/vehicle ferries. Horizontal loading container ships and pallet ships, loaded by lift trucks or tractors with trailers, are sometimes considered RO/RO ships as well.

RO/RO ships of all types have a high cargo cubic to deadweight ratio, and have certain common features in the arrangement of cargo spaces:

- Long clear cargo decks without transverse bulkheads with deck heights to accommodate vehicles.
- Side, stern, or bow ports and ramps for ship-shore cargo transfer. Ramps are sometimes part of the terminal facility, as in ferries and train ships. Many designs place side ports near the ends of the ships to take advantage of the curvature of the shell plating in the construction of the loading ramp. The curved plating forms the outer chord of a truss with the flat vehicle travel surface forming the inner chord.
- Decks designed to withstand concentrated vehicle wheel loads.
- Deck heights to match a particular range of vehicle or cargo unit heights.
- Clearances for stowing and turning vehicles.
- Single cargo deck or internal ramps or elevators for vertical distribution of the cargo. Ramps may be permanent fixtures or be designed to stow in the deck or overhead to permit additional cargo stowage.

Most modern RO/RO ships range in length from 400 to 640 feet, with a deadweight range of 10,000 to 27,000 long tons. Machinery spaces are usually located aft, often wholly beneath the lowest RO/RO cargo deck. The requirement for clear decks and specific deck heights calls for a ship structure significantly different from that of a standard transversely framed cargo ship. The strength provided in ordinary cargo ships by transverses, which would normally be carried above the freeboard deck to the uppermost continuous deck, is provided instead by deep web frames and beams, spaced 8 to 12 feet apart. Plating between the webs at deck and side is normally reinforced by longitudinal frames, although intermediate transverse side frames may be used. Because of the deck strength required to carry vehicle wheel loads, decks are thicker, and deck longitudinals heavier and more closely spaced than in similar sized general cargo ships. The combination of heavy cargo deck structure, longitudinal framing, and great hull depth due to the height of the cargo decks, give the RO/RO ship longitudinal strength usually well in excess of statutory or classification society requirements. Typical RO/RO ships are shown in Figure B-13. Characteristics of some specific types of RO/RO ships are discussed in the following paragraphs.

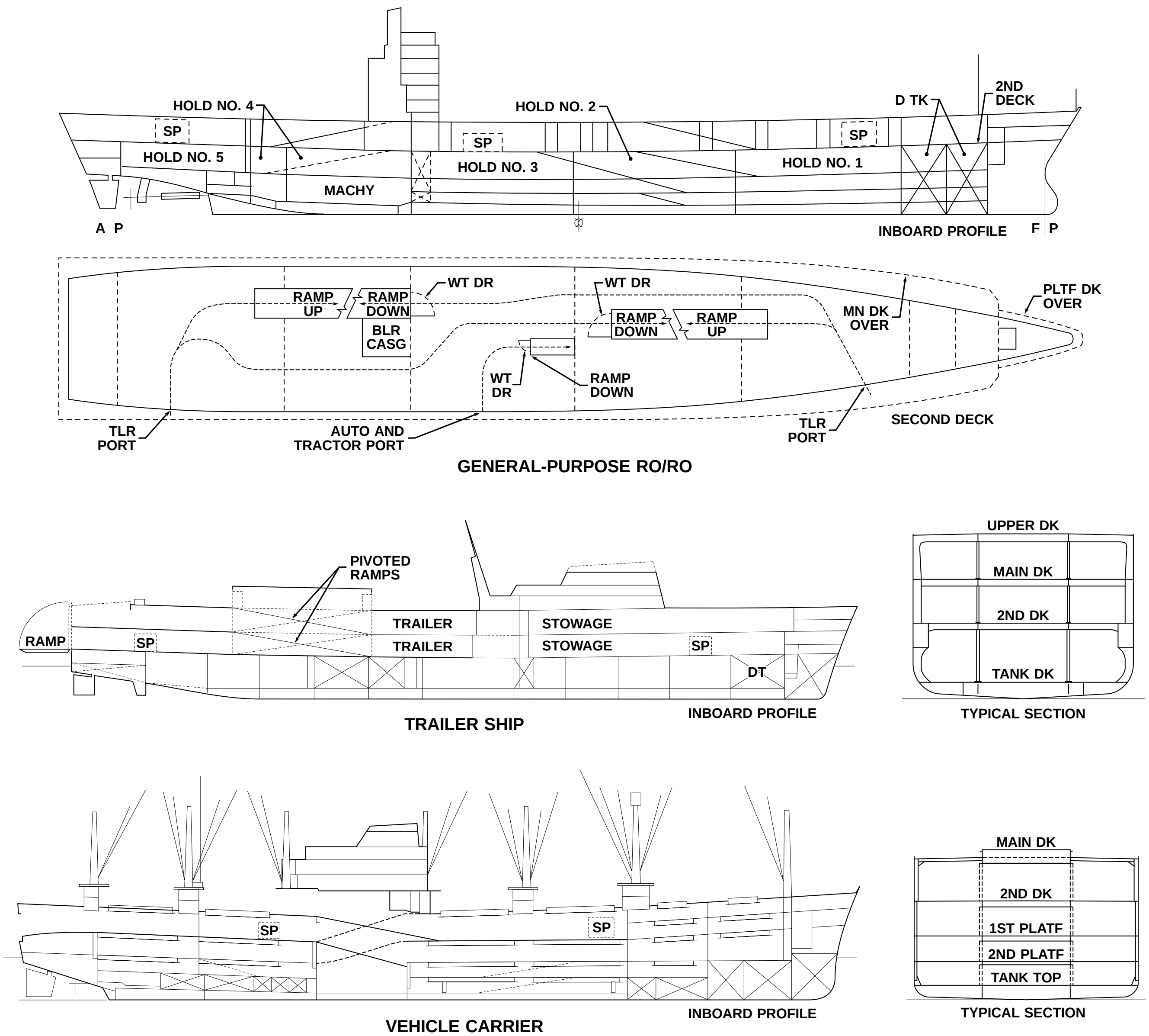


Figure B-13. Roll-On/Roll-Off Ships.

B-6.7.1 Vehicle Carrier. Vehicle carriers can be broadly classed as vehicle/passenger ferries and straight vehicle carriers, which may be designed to carry automobiles, large commercial and military vehicles, or both. Typical large vehicle/passenger ferries can accommodate up to 320 cars and 1,200 passengers for short voyages. Straight vehicle carriers have much less passenger space, but can carry up to 3,200 vehicles. Automobiles are typically stowed low in the ship, while trucks and other commercial vehicles requiring greater stowage length and height are stowed on the longer higher decks. Carriers designed to handle large commercial and military vehicles can also operate as trailer carriers or horizontal loading container ships. In some carriers, vehicles are carried above the bulkhead deck on movable nonwatertight decks so deck height can be adjusted to accommodate particular types of vehicles.

The vehicle carrier shown in Figure B-13 is designed for rapid loading and discharge of military wheeled vehicles under their own power to and from piers, lighters, and landing craft. As a secondary task, the ship is capable of transporting general cargo and vehicles loaded by conventional overhead means. Cargo is stowed in two 135 foot vehicle holds amidships and smaller holds in the bow. Vehicle holds are interconnected by fixed ramps in the center of the ship, which pass above and through the machinery space. Vehicles are driven on board and then over the ramps from one deck to another until they reach their stowage spot. All decks, including the weather deck, may be loaded from the side and stern ports. 'Tween deck hatch covers are flush, and designed to withstand the local loads imposed by the vehicles. Machinery spaces are located beneath the second deck closures. Characteristics of the vessel are given in Table B-24.

Table B-24. Typical Vehicle Carrier.

Dimensions (ft-in)	
Length overall	499-0
Length between perpendiculars	465-0
Beam	78-0
Depth to main deck	48-9
Design draft	22-0
Maximum draft	27-1
Speed and Power	
Design sea speed, kts.	18
Shaft horsepower	13,200
Deadweight and Displacement (lton at maximum draft)	
Lightship	8,175
Total deadweight	10,111
Cargo deadweight (fuel for 15,000 miles)	7,551
Full load displacement	18,286
Capacity	
Bale capacity of all vehicle and cargo spaces, omitting driveways, ft^3	766,500

B-6.7.2 Train Ship. Train ships are designed and constructed to carry freight cars, and sometimes locomotives or passenger cars, on short transits between railheads. They are usually longitudinally framed, with the car deck designed to provide the required structural support directly under each track. Ship beam is based on the number of tracks, the required clear width in way of the tracks (usually 11 to 12 feet), access requirements, and requirements for structure in way of pillar lines and at the side. Hull lines are selected to allow a car deck layout such that rail tracks can be arranged with radius of curvature greater than 160 feet. Deck heights are selected to accommodate the tallest cars carried, usually about 18 feet clear height for box cars, higher for flat cars with trailers. Machinery casings and access ladders are given minimum width and located in way of pillar lines or side structure. The most common type of crane ship is the single-deck, stern loading type. In a variation of this type, cars are transferred singly to a lower deck with an elevator. Multi-deck designs with connected ramps are generally impractical because of the severe grade limitations that apply to railroads (5 degrees or less). Securing fittings normally consist of jacks and hold down lashings at the corners of the cars. The jacks brace against a jack rail and take part of the cars weight off the truck springs. The cars are then secured to the jack rail by turnbuckle-tensioned lashings. This securing method renders the car springs inoperative and prevents the buildup of ship motion caused car movements which might synchronize with the natural period of the car on its springs. Securing fittings are designed for a maximum expected roll amplitude, normally about 20 degrees.

Table B-25. Trailer Ship Characteristics.

Dimensions (ft-in)	
Length overall	518-0
Length between perpendiculars	500-0
Beam	78-0
Depth to upper deck	57-6
Design draft	19-0
Speed and Power	
Design sea speed, knots.	20-0
Shaft horsepower, approx.	16,500
Deadweight and Displacement (long tons at scantling draft)	
Lightship	6,680
Total deadweight	4,400
Full load displacement	11,080
Cargo Capacity Trailers, (35 ft)	200
Crew	47

B-6.7.3 Trailer Ship. The factors dictating the arrangement of cargo spaces in trailer ships are similar to those for train ships, but required clearances, point loads on decks, and minimum turning radii are all generally smaller, while allowable deck grade angle is much greater. In some designs, trailers are loaded in rows, following wheel tracks consisting of a guide fitting on deck that projects into the space between the dual tires on one side of the trailer. Trailers are loaded and discharged by special tractors which may be carried on board or provided at the terminal. Multi-deck designs with interconnecting ramps, like that shown in Figure B-13, are common. Trailer ships are normally designed for short runs with assorted sized trailers, as it is more economical on long voyages to separate standard (ISO) trailers from their chassis and transport them as containers. Characteristics for a typical trailer ship are shown in Table B-25.

B-6.8 Barge Carriers. The Barge Carrier is another variation on the unitized cargo concept, employing larger containers (barges) that are lifted to and from the water instead of the dock. Barge carriers are particularly suited to traffic between ports at the entry to inland waterways and undeveloped ports. Since the barges are loaded directly to and from the water, cargo can be delivered without container handling facilities. Three types of barge carrier are described in the following paragraphs: the LASH (Lighter Aboard Ship), the SEABEE, and the BACO (Barge Container). LASH and SEABEE ships are shown in Figure B-14.

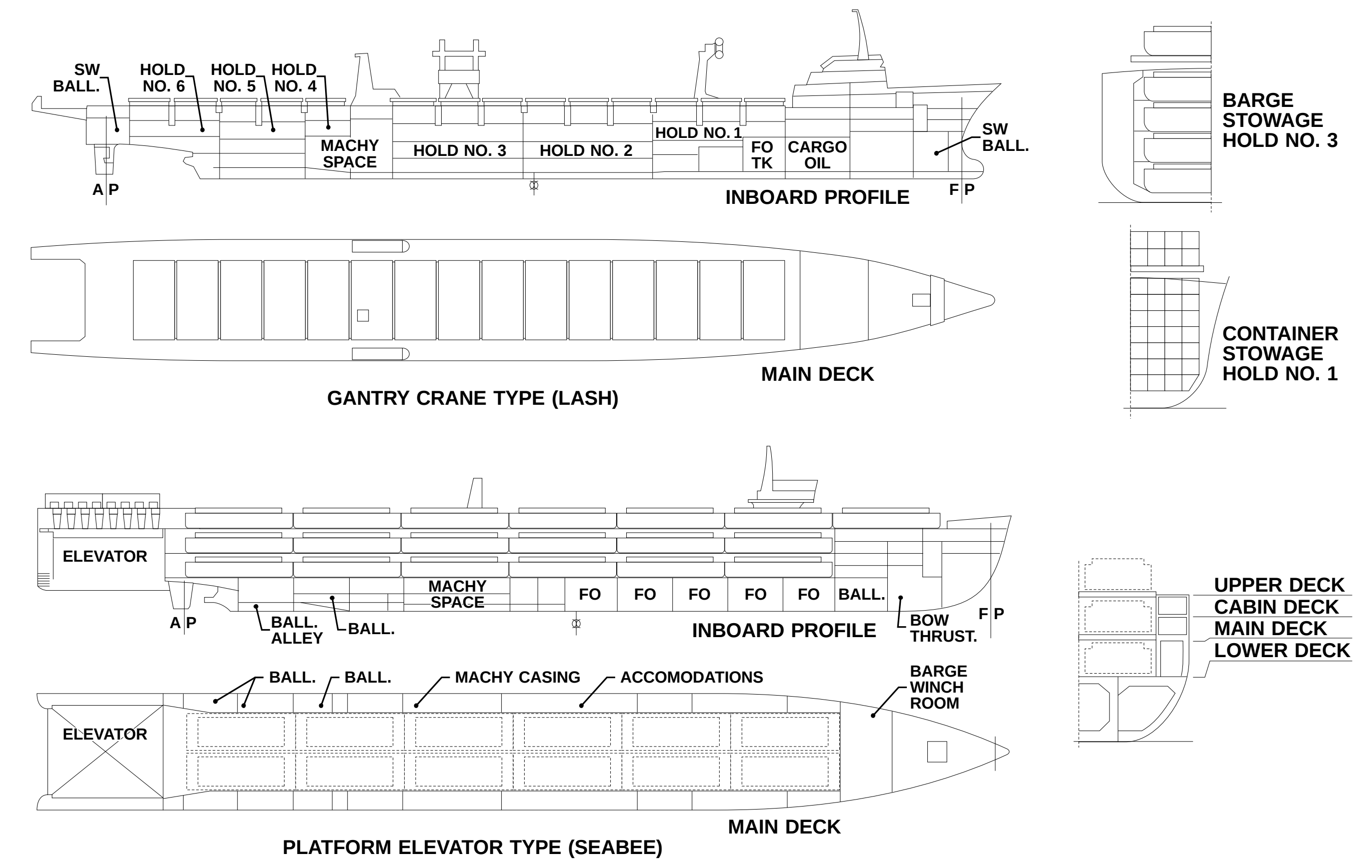


Figure B-14. Barge Carriers.

B-6.8.1 LASH Ship. LASH ships are large, (up to 46,000 tons deadweight) and relatively fast (10 to 22 knots). LASH characteristics are given in Tables B-31 and B-34 (Pages B-51, B-54, and B-55). LASH lighters measure 61.5 feet long by 31 feet wide by 13 feet high, and hold up to 20,000 cubic feet or 375 long tons of cargo. The lighters are fitted for stacking with large locking (peck and hale) lugs at the corners of the deck and matching recesses on their bottoms. The barges are lifted to and from the water at the stern by an installed 455 long ton travelling gantry crane that engages the deck lugs. The vessel shown can carry up to 46 barges stacked in holds similar to the way containers are stacked, with an additional 30 stacked two deep on deck over the hatch covers. The forward hold may be fitted with cell guides for up to 180 containers, with another 164 stacked on hatch covers and along the wing walls, reducing barge capacity to 61. A stretched (893 foot) version can carry up to 89 lighters for a total cargo deadweight of 33,375 long tons. River-type towboats (see Paragraph B-6.15), specifically designed and fitted for stowage atop lighters and handling by the gantry crane, may be carried to handle the lighters in undeveloped ports.

B-6.8.2 SEABEE Ship. SEABEE barges measure 97 feet long by 35 feet wide by 12.5 feet high with a 1,000 ton cargo capacity. The barge size was selected to match the dimensions of standard barges on U.S. inland waterways. The SEABEE ship is about the same size as a LASH ship. SEABEE characteristics are given in Table B-34 (Pages B-54 and B-55). With a deadweight of 38,000 tons, the SEABEE ship can carry 38 barges. Barges are loaded by an elevator located at the stern and moved forward by a winch located forward of the barge decks. Two 'tween decks are used to store the barges, and machinery spaces are located below them. The machinery space extends into a box-like structure outboard the barges on both sides of the ship. These spaces are largely used for accommodations and ballast tanks. In addition to the barges, SEABEE ships have a container capacity of about 950 TEU (mostly on deck) and can accept RO/RO cargo. Because of their spacious and unobstructed barge decks, SEABEE ships are particularly well suited to carrying oversize military and industrial cargo, such as aircraft, watercraft, and tracked vehicles.

B-6.8.3 Barge Container (BACO) Ship. BACO ships are similar in arrangement to LASH and SEABEE ships, but employ a float-on/float-off loading method. The ship is ballasted, the hold is flooded, and the barges are floated in through the doors in the bow. After loading, the doors are closed, the hold is pumped out, and the ship is ready to sail. Unlike other barge carriers, BACO ships are commonly fitted with cargo gear, including cranes with a typical capacity of 800 tons. Characteristics of a the BACO barge and a typical ship are given in Table B-26. Typical cargo capacity is twelve barges and 500 to 620 container TEU.

Table B-26. BACO Ship.

	BACO Ship	Barge
Dimensions, ft-in		
Length overall	669-7	78-9
Beam	93-6	31-2
Draft, load	21-10	13-11
Deadweight, tonne (lton)	21,000 20,672	800 787.5
Service Speed, kts	15	

B-6.9 Tankers. Oil tankers, illustrated in Figure B-15, are unique in that the cargo rests directly on the skin of the ship. Most oil tankers are single-skinned, although recent U.S legislation will require double bottoms and/or cofferdams. Tankers are roughly grouped according to size and service:

Type:	*Deadweight, lton:*	*Service:*
Coastal	less than 15,000	crude and refined products
Handy or small size	6,000 to 35,000	mainly refined products
Mid size	35,000 to 75,000	crude and refined products
Large	75,000 to 160,000	mainly crude
Very Large Crude Carrier (VLCC)	160,000 to 300,000	exclusively crude
Ultra Large Crude Carrier (ULCC)	above 300,000	exclusively crude

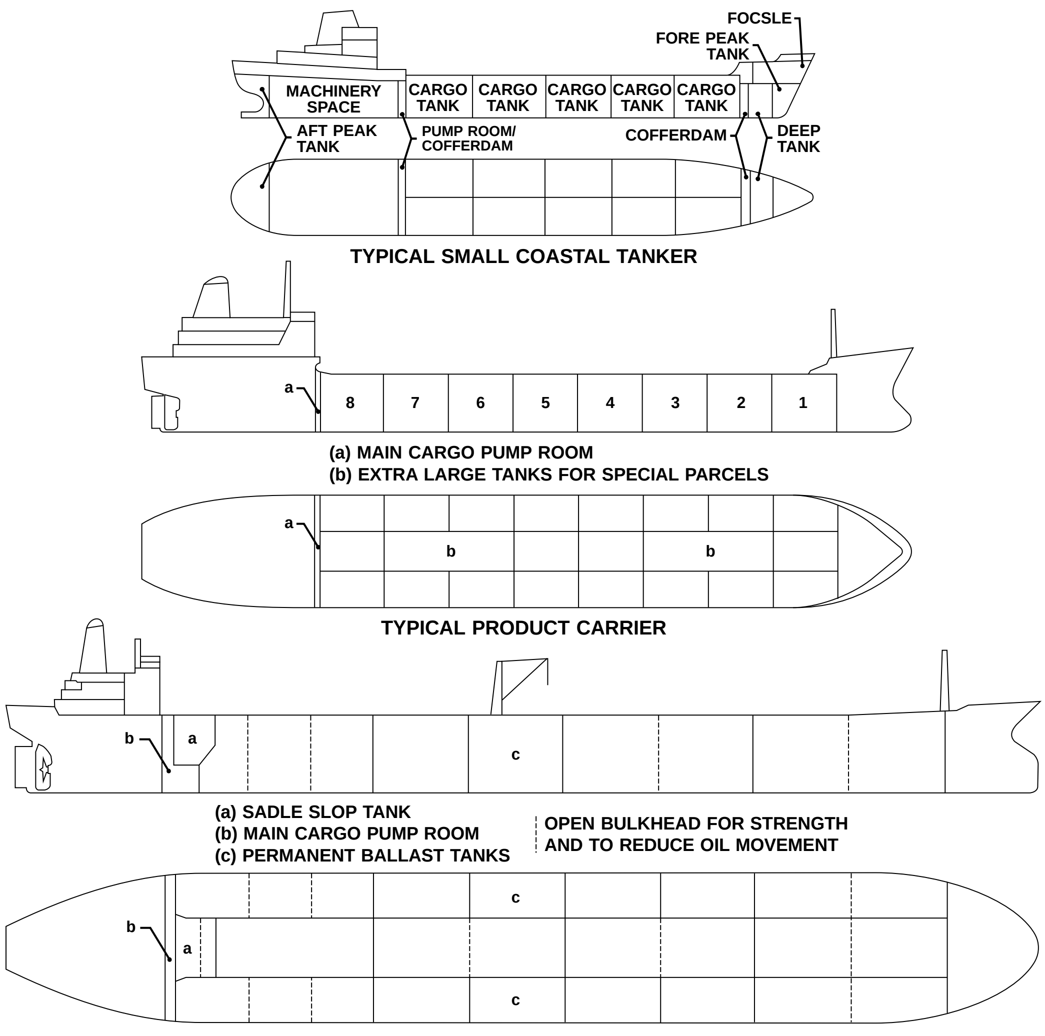


Figure B-15. Tankers.

Characteristics of various-sized tankers are given in Tables B-31, B-32, and B-34 (Pages B-51, B-52, B-54, and B-55). Cargo space in tankers is subdivided by a number of oil-tight bulkheads throughout the length of the *tank deck*. In mid-size and large tankers, cargo space is further subdivided by two longitudinal bulkheads to give several sets of three tanks abreast, numbered from forward aft (center, and port and starboard wing tanks). The wing tanks typically have one half to two thirds the capacity of the adjacent center tank. In small tankers there may be only one longitudinal bulkhead, or none at all, while very large tankers may have 5 tanks abreast.

All tankers have machinery spaces aft of the cargo tanks. Some older designs have a midships bridge and accommodation unit, but all working spaces are isolated from other areas by cofferdams. To minimize the risk of leakage of oils or vapor into other compartments, a pair of bulkheads, forming a cofferdam, are fitted at each end of the tank section. In some ships, pumprooms serve as cofferdams. Ships designed to carry different products simultaneously may separate groups of tanks by cofferdams. Most tankers have a deep tank for ship's fuel between the cargo tank section and the fore peak tank. Additional fuel may be carried in double-bottom tanks under, and wing tanks abreast, the machinery spaces. Some vessels have a dry cargo hold above the forward deep tank.

To reduce the still water bending moment and allow lighter scantlings, large tankers are often designed with permanently empty tanks near midships. Since virtually all tankers tend to hog when empty, it is important to avoid loading cargo into the extreme bow and stern sections without first placing some weight in the center. Tankers less than 650 feet in length may be framed on either a longitudinal or combination system. Longitudinal framing is required for larger tankers by the construction rules of most classification societies and regulatory agencies. Transverse bulkheads are normally located not more than two-tenths of the ships length apart. Perforated swash bulkheads are fitted in tanks longer than one-tenth the ships length or 45 feet, to provide transverse strength and dampen fore and aft movement of the cargo. The longitudinal framing extends throughout the length of the tank section and may extend to the ends of the ship, but it is customary to employ transverse framing at the ends of the ship, including the machinery spaces. A double bottom is normally fitted under the machinery spaces.

Cargo pumping arrangements in oil tankers are quite extensive, since a number of grades of oil may have to be loaded, transferred, and discharged from tank to tank through a pipe network without risk of contamination of one grade by another. Tanks for heavy oils, molasses or other viscous fluids are fitted with heating coils. Pumprooms may be placed at both ends of the tank section or between tank groups, but most modern tankers have only one pumproom, between the tank section and the machinery space.

B-6.9.1 Tanker Piping Systems. Most modern tankers are fitted with a direct pipeline system for handling cargo. Tanks are divided into groups or systems, with a different pump and line for each system. Figure B-16 shows two possible pipeline arrangements for an 18 tank ship. The upper illustration incorporates three main cargo pumps, each handling two sets of tanks (two center tanks and four wing tanks). The lower illustrates another possible arrangement for the same type of ship. In this case only two pumps are fitted; one for centers, one for wings. In both cases, a separate line runs from each pump along the bottom of the tank range to the tanks in its system. Shorter sections of pipe branch off from the main lines to each individual tank. These pipelines vary in diameter from 10 to 12 inches on smaller tankers to 36 inches on VLCC's. Valves are operated by metal reach rods connecting each valve stem to a handwheel on the main deck. Chapter 2 of the *U.S Navy Ship Salvage Manual, Volume 5* (S0300-A6-MAN-050) offers a detailed treatment of ship fuel and cargo oil systems.

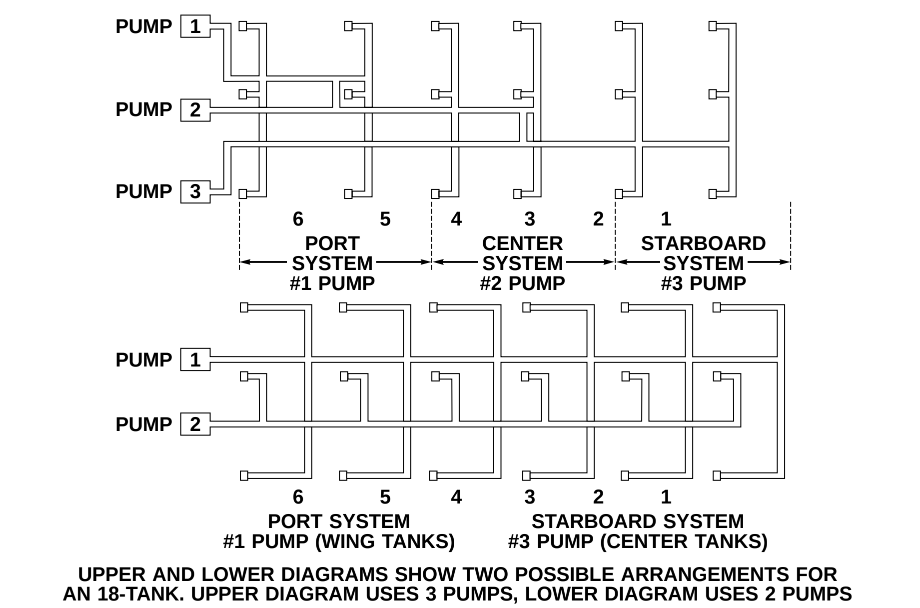


Figure B-16. Tanker Piping Systems.

B-6.9.2 Tank Cleaning. Tanks are routinely cleaned to prevent contamination of a clean cargo or seawater ballast by residues of a previous cargo, or to render them gas-free in preparation for personnel entry for inspection, maintenance, or repair. Tank washing machines, consisting of fixed or rotating nozzles, are installed on most modern tankers. The nozzles deliver seawater in the form of a high pressure, rotating stream. Water is delivered by a special pump in the engine room, or by the cargo pumps. The piping system may include heating coils to furnish hot water. Washing temperatures pressures, which may be as high as 180 degrees Fahrenheit and 180 psi, vary with the tank coating and the type of residue being cleaned. The cleaning slops are drawn from the tank by the stripping system for transfer to slop tanks. Various tank coatings are used in many tankers to ease cleaning.

Some crude oil carriers are fitted for crude oil washing (COW) of tanks. The tanks are crude washed during discharge to loosen and remove the waxy residue and sludge clinging to the tank inner structure that otherwise would not be discharged (and therefore not earn income). The washing fluid is crude oil delivered to the rotating nozzles by the cargo pumps.

B-6.9.3 Coastal (Small) Tankers. Coastal tankers have simple layouts and are used to transport a variety of products. Coastal tankers are substantially smaller (15,000 deadweight tons or less) than most long-haul tankers, in order to maintain shallower drafts for entry into shallow water ports, or through inland waterways. Most coastal tankers are limited to one or a few types of cargo in normal service to reduce the need for frequent tank cleaning and multiple cargo handling systems. Many are built with shell-to-shell tanks without longitudinal bulkheads. They may have double bottoms.

B-6.9.4 Mid-size Tankers. Mid-size tankers may be designed to carry either crude oil or refined products. Many *product carriers* are designed to carry several cargoes isolated from each other in separate parcels. The *parcel carrier* concept permits one ship to carry various types of incompatible products at the same time. This ship type is commonly employed in moving products between refineries, or from refineries to customers, to and from storage points, and other cabotage operations. A fore and aft catwalk is commonly built between the superstructure and the forecastle to allow safe passage when the ship is laden. The catwalk also forms a convenient support for the cargo, steam, and foam-smothering pipelines that run along the upper deck.

B-6.9.5 Large Tankers. ULCCs with deadweights in excess of half a million tons have been built, although the current trend is for somewhat smaller vessels in the 100,000- to 150,000-ton deadweight range. The catwalk seen in smaller tankers is seldom found in VLCCs and ULCCs because these vessels have a railed off section running fore and aft along the main deck centerline for crew passage.

B-6.9.6 Double-hull Tankers. Recent controversy surrounding double hulls and double bottom construction includes the merits of each type of construction as they apply to the salvor. Double bottoms or hulls may add an increased potential for capsizing or explosion, making the salvage operation more hazardous and thus more likely to fail. Current debate revolves around the required depth of the double hull. In spite of inherent hazards, a double hull offers certain advantages over single skin construction, provided that only the outer hull is ruptured:

- The prevention of immediate pollution in the event that grounding or collision ruptures only the outer hull.
- Cargo piping is more likely to remain intact and operational.
- Lost buoyancy is restricted to the smaller double bottoms which, in turn, can be more easily pressurized with air. The smaller "bubble" is more likely to hold during refloating, and its loss would likely be less catastrophic.
- The ability to stabilize a casualty in the early stages to prevent further grounding or loss of structural integrity.
- The availability of a wider range of options in developing and implementing a salvage plan, like countering off-center weight with selective ballasting.

Additional discussion on the merits of double-hull and double-bottom construction can be found in the *Report of The Committee on Tank Vessel Design*, November 1990, a comprehensive study by the National Academy of Sciences.

B-6.10 Bulk Carriers. In its broadest sense, the term bulk carrier embraces all ships designed primarily for the carriage of solid or liquid cargo in bulk form, and so would include tankers. In ordinary usage, however, the term is normally used for those vessels designed for the transport of solid bulk cargos, typically grain and similar agricultural products, and mineral products like coal, ore, stone, etc., on one or more voyage legs. Like tankers, the general arrangement of cargo spaces is dictated by the facts that the cargo is in the form of homogeneous particles of more or less uniform size, and can be transferred by blowers, conveyors, or grab buckets. Cargo spaces are divided into holds to meet structural and subdivision requirements, to restrain cargo movements and resulting upsetting moments, to permit the carrying of different cargoes simultaneously, and to provide for ballasting. Machinery is invariably aft, and the nonperishable nature of the cargoes leads to speeds in the 12- to 16-knot range, with attendant full hull forms.

Bulk carrier general arrangement and size range are similar to that of tankers, as shown in Figure B-17. Single-purpose bulk carriers are generally designed as *ore carriers*, built to carry heavy cargoes stowing at 25 cubic feet per long ton or less, or *dry bulk carriers*, for grain and similar cargoes stowing at 45 to 50 cubic feet per ton. Stowage factors for various bulk cargoes are given in Appendix E of the *U.S. Navy Ship Salvage Manual, Volume 1* (S0300-A6-MAN-010).

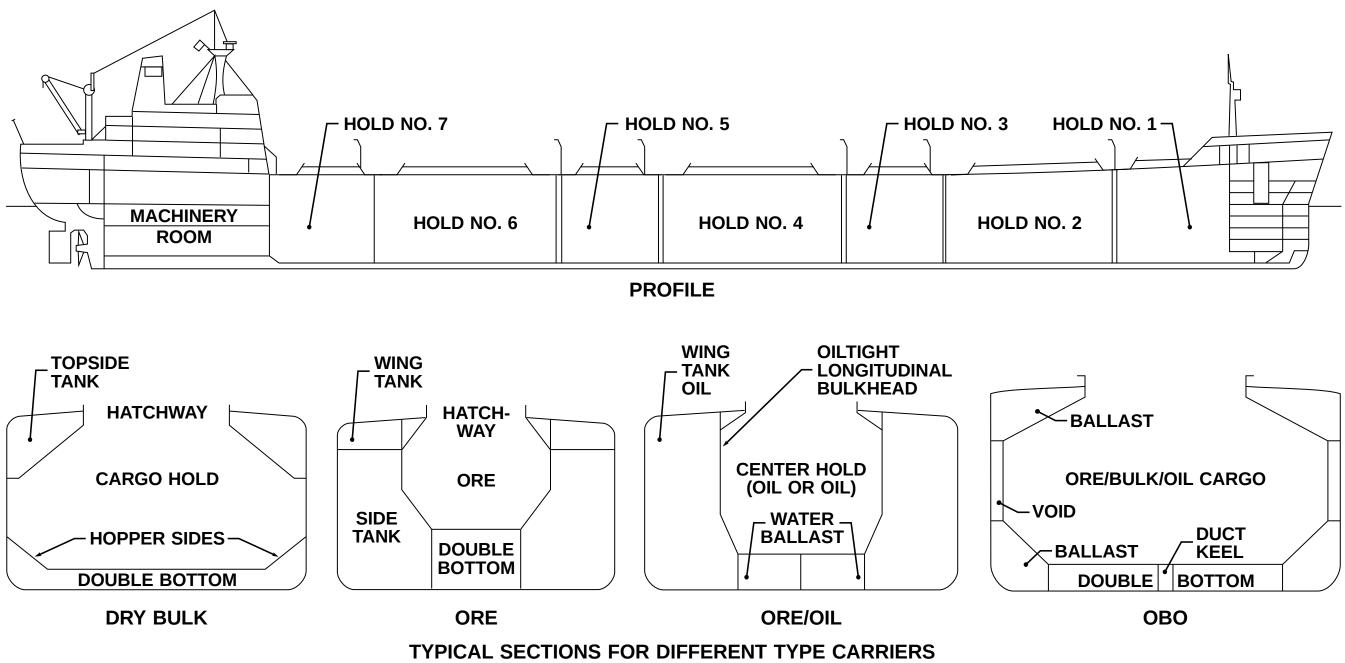


Figure B-17. Bulk Carriers.

Relatively small volumes of dense ores and similar cargoes will settle a ship to her summer load line. Holds on ore carriers are therefore quite small, bounded by broad wing tanks and deep double bottoms, as shown in Figure B-17. The double bottom and longitudinal bulkheads are of heavy construction to carry the heavy ore load. The narrow hold breadth limits transverse weight shifts and the depth of the double bottom is sufficient to keep the center of gravity of the ore high enough to prevent stiff rolling in a seaway. Large volume wing tanks are used for ballast.

Designed for low-density cargoes, dry bulk carriers require much greater hold volume than ore carriers, and therefore have much shallower inner bottoms, as shown in Figure B-17. In some designs the topside tanks are omitted or fitted with bolted plates in the sloping plating facing the hold. When very light cargoes are carried, the plates are removed and the tanks are filled along with the hold; the cargo in the tanks feeds into the hold by gravity when discharging. Larger carriers are sometimes built with an inner side shell, which eases hold cleaning and provides additional ballast space.

Shallow double-bottom bulk carriers are sometimes designed to carry high-density cargo, by arranging them with alternate long and short holds. High-density cargo is loaded only in alternate holds to keep the center of gravity high enough to prevent excessive metacentric height. The double-bottom structure under the holds intended for heavy cargo is augmented. The alternating cargo distribution causes high vertical shear near the bounding bulkheads, which may require increased shell scantlings.

With the increase in industrial demand for raw materials paralleling that for petroleum, the design of bulk carriers, like tankers, also evolved to include larger hulls. Bulk carrier deadweights range from quite small to over 200,000 tons. In order to increase the proportion of payload operation above the 50-percent level typical of most straight bulk carriers (for tankers or dry bulk carriers operating between specific ports, cargo is often carried on only one leg of the journey), a trend toward combination carriers began about 1950. At first, these were dual purpose ships (ore/oil, bulk/oil) which carried different cargos on separate legs of a voyage cycle consisting of two or more legs. This development has evolved into combination carriers known as ore/bulk/oil ships (OBO). Despite differences, bulk carriers of all types have certain features in common:

- Single cargo deck, without ’tween decks.
- Machinery aft of cargo spaces so shaft tunnel does not interfere with discharging gear.
- Large ballast capacity.
- Double bottoms under bulk cargo holds.

To facilitate rapid cargo discharge and minimize cleaning requirements, holds are designed with a minimum of internal obstructions that might catch and hold cargo. Bulkhead stiffening is attained by the use of corrugated plate rather than welded stiffeners. Hold cross section, as shown in Figure B-17, is arranged so that cargo is self-trimming and self-loading:

- Cargo will flow outwards from the point of discharge of bucket grabs or gravity chutes to fill the entire cargo space with a minimum of hand trimming.
- The narrowing width at the top of the hold limits transverse cargo shifts when the hold is not completely filled.
- During discharge, remaining cargo will flow to a fairly small area where it can be picked up by the discharging equipment.

Holds of different lengths may be distributed throughout the length of the ship for flexibility in cargo distribution; cargoes of varying densities can be distributed so as to keep the longitudinal bending moment within acceptable limits. Except for equipment to open or remove hatch covers, most bulk carriers are without cargo gear. Cargo is loaded by gravity chutes or derrick grabs and discharged by grabs, conveyor systems, or in the case of grain and similar light cargo, by suction. Some bulk carriers are built as self unloaders, either by the provision of derrick grabs, or by trimming the cargo spaces to belt conveyers running under the holds to a bucket conveyer which transfers the cargo to another belt conveyor on a long unloading boom. Conveyor type self-unloaders are fairly common on the Great Lakes (see Paragraph B-6.11). Combination carriers are fitted with cargo pumps and piping systems for discharging oil cargoes.

B-6.10.1 Ore/Oil Carriers. Cargo spaces in ore/oil carriers are divided into center and wing tanks by two longitudinal bulkheads, as shown in Figure B-17 (Page B-43). A deep double bottom lies under the center tank, which is also the ore hold. Oil and ore are not carried simultaneously because of the danger of explosion, and only the center tanks are used for ore. Construction is similar to that of oil tankers, except for double bottom and the large oiltight hatches over the centerline holds. The main structure of the ship must meet the standards for ore carriers, while bulkheads and other appropriate parts of the structure must meet oil tanker standards.

B-6.10.2 Ore/Bulk/Oil (OBO) Carriers. The cargo cross section of an OBO carrier is similar to that of general dry bulk carrier, but significantly stronger, as the bulkheads must be oiltight and the double bottom must carry the high density ore load. The typical bulk carrier self-trimming cargo hold and wing tank arrangement, together with holds of different lengths, provides the alternative distribution patterns required for utilizing the full deadweight for any of the three types of cargo (or ballast) while maintaining proper stability and trim.

Table B-27. Typical OBO Characteristics.

Dimensions (ft)	
Length overall	815-0
Length between perpendiculars	775-0
Beam, molded	104-6
Draft, molded, full load (summer)	41
Speed and Power	
Service speed, knots	15.85
Maximum continuous Bhp (metric) at 114	18,400
rpm	16,800
Normal bhp (metric) at 110 rpm	
Deadweight and Displacement (long tons)	
Light ship weight	15,528
Total deadweight (maximum)	63,410
Cargo deadweight (ore, oil)	61,419
Cargo deadweight (coal)	53,303
Cargo deadweight (grain)	60,620
Cargo Capacity (ft^3)	
Cargo holds (grain)	2,727,933
Cargo tanks (98 percent full)	2,947,624

The general arrangement and basic loading conditions for a typical OBO carrier are shown in Figure B-18 and described in Table B-27. Only when carrying coal, grain, and similar low density cargos are all the holds used. Because of its greater density, a full ore cargo requires only the four long holds. Liquid cargos are distributed among various holds and wing tanks in accordance with the liquid density and requirements for proper stability and trim; in general, tanks are either filled or left empty. Several special features for liquid cargos are incorporated, including provisions for tank cleaning and heating, and remote control of all cargo and stripping valves. The short holds and wing tanks are filled when sailing in ballast condition.

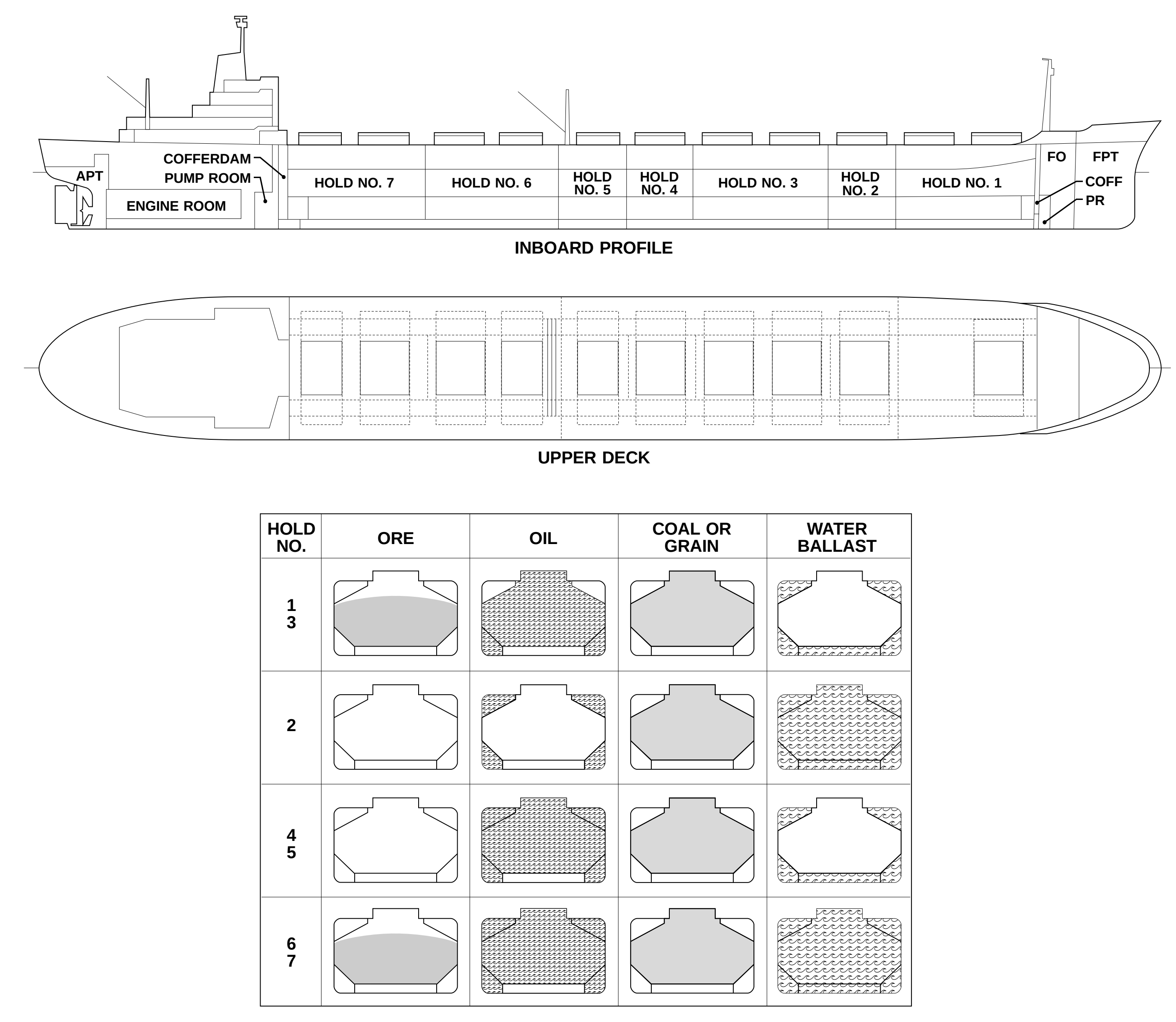


Figure B-18. OBO Profile, Deck Plans, and Loading Conditions.

B-6.11 Great Lakes Bulk Carriers. As the principal commodities carried on the Great Lakes are coal, ore, limestone, and grain, the majority of the cargo vessels working the lakes and the St. Lawrence River are bulk carriers, commonly called *freighters*. Because the corrosion rate in the cold fresh water of the Lakes and Seaway is virtually negligible, Great Lakes ships generally have a useful life of 50 to 60 years (it is not uncommon to find vessels built in the early 1900s in service on the Great Lakes and associated river systems). The long ship service life, combined with the limitations imposed by channel and lock dimensions, and well established trading routes and terminals, has discouraged drastic changes in ship form and arrangement. Ship design changes in Great Lakes vessels have mainly involved machinery plant improvements, including the general trend towards diesel powering, and measures to improve maneuverability, such as fitting controllable pitch propellers, Kort nozzles, twin rudders, and bow thrusters.

Great Lakes freighters are designed to operate between the same loading and unloading docks throughout their lives, and to drydock at any of the long established facilities on the Lakes. Cargo hatches are spaced on 12- and 24-foot centers to coincide with the width of loading docks at Great Lakes ports, where cargo chutes are spaced at 12-foot centers. Cargo gear is more commonly fitted on Lake freighters than ocean going dry bulk carriers. Self-unloading gear for a typical 37,500 deadweight vessel can discharge 4,000 tons of coal per hour using a hoisting and sluing boom, controlled from a remote console in the forecastle. Remote actuators operate gate valves allowing the cargo to pass downwards from the hopper holds onto belt conveyors. These belts carry cargo to a vertical bucket conveyor and thence to a belt conveyor on a sluing boom, which may be nearly 300 feet long. Figure B-19 shows profile and cross section of a typical Great Lakes self-unloader.

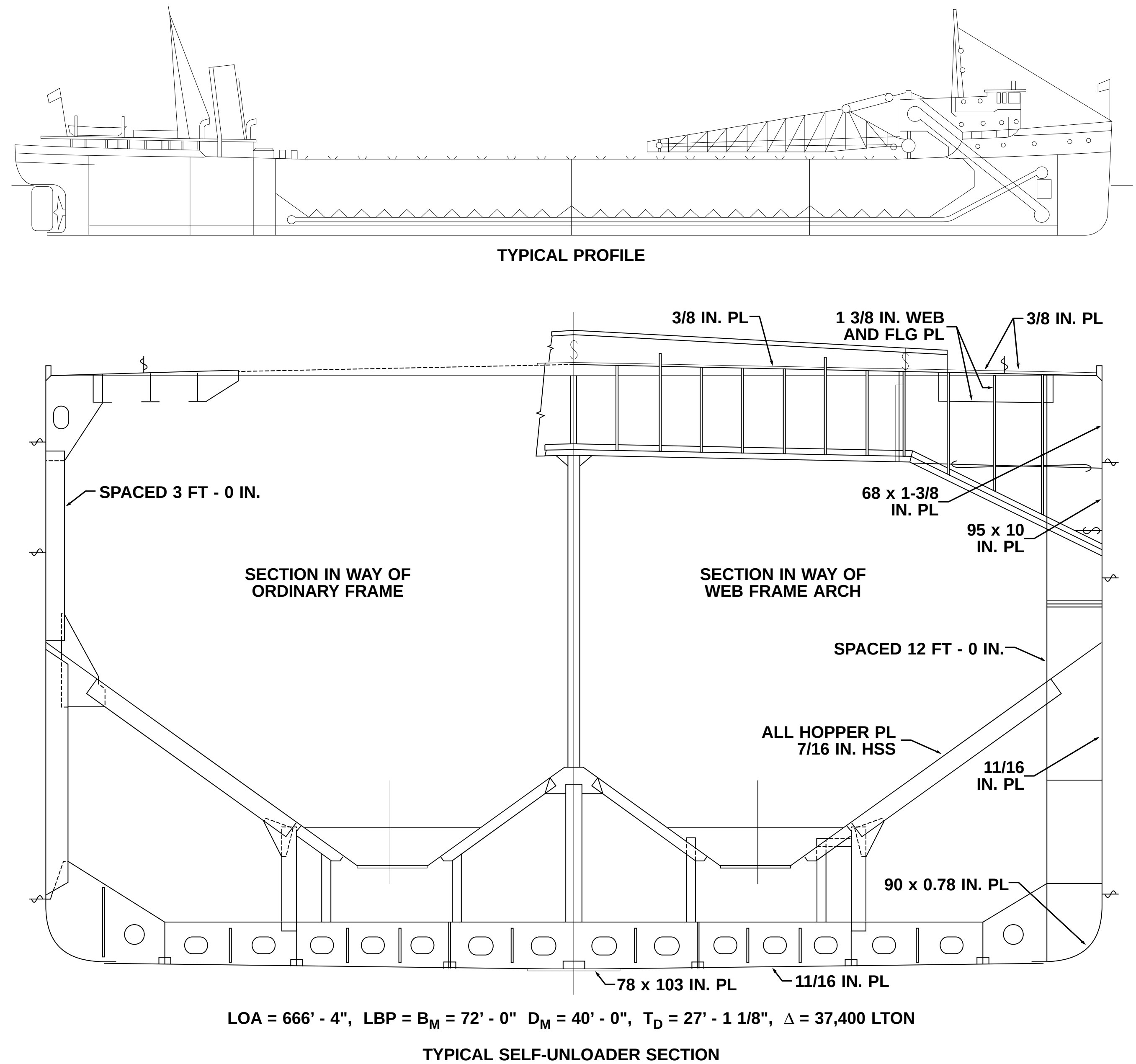


Figure B-19. Great Lakes Bulk Carriers.

Great Lakes cargo vessels range in size from 10,000 to 80,000 tons deadweight. Size limitations of 730 feet in length, 75-foot beam, and 27-foot draft are imposed by the St. Lawrence Seaway and the locks and channels linking the lower lakes (Erie, Ontario, and St. Clair). The Sault Ste. Marie ("Soo") locks linking Lakes Huron and Superior can accommodate vessels up to 1,000 feet in length with beams of 105 feet and drafts of 32 feet. Some newer vessels are built to these dimensions for service on only the upper lakes (Huron, Superior, Michigan).

Great Lakes vessels are easily identified by their great length and arrangement; machinery aft of all cargo holds, extensive parallel midbody, pilot house usually well forward rather than on the aft deck house, and straight, nearly vertical stems. A rectangular bar stem or heavy pipe is still used to a great extent, because of the custom of *winding*—turning a vessel into a narrow channel by going ahead with the rudder hard over and a bow line secured to the dock. As the ship comes around the stem is under heavy pressure as it rides against the dock. A vessel with a raked stem would tend to climb up on the dock or overhang the dock and foul the dockside cargo handling equipment. Stem bars of Lakes vessels also require frequent replacement, and straight bar or pipe stems can be procured more economically and with less lead time than custom castings or built up stems.

The high length to breadth ratios (8 to 10) typical of Great Lakes vessels virtually mandates longitudinal framing. Experience has shown, however, that longitudinally framed vessels are more susceptible to lock damage than transversely framed vessels. As lock transits are a frequent occurrence, the sides of Lakes vessels are transversely framed, with the inner bottom and deck longitudinally framed. The side-framing is usually of greater strength than customary in seagoing vessels of the same size, with deep frames between hatches. In other respects, the scantling of Great Lakes ships are less than those of similar sized ocean going vessels, as they are designed for less severe wave conditions.

Automatic self-tensioning mooring winches are fitted on most Lakes vessels, essential on vessels using the Seaway locks, unless special arrangements can be made for mooring winches to be operated manually. Steering gear is usually designed for an operating angle of 45 degrees with the rudder stops set at 47 or 48 degrees, as compared with 35 degrees for the most oceangoing cargo ships. The 45-degree angle is essential for maneuvering in close quarters and when winding. The steering gear of a Great Lakes vessel is more powerful than for an oceangoing cargo ship because ship specifications normally the rudder to be able to shift from hard-over to hard-over (90 degrees) in 20 seconds or less.

B-6.12 Liquified Gas Carriers. Most liquified gas carriers are designed for the transportation of condensed hydrocarbon gases, although ammonia and other gases are sometimes carried in bulk liquid form. Table B-28 lists pertinent characteristics of common liquified gases.

Table B-28. Characteristics of Liquified Gases.

Gas	Propane (LPG)	Butane (LPG)	Methane (LNG)	Ammonia
Boiling Point (degrees F)	-44	31	-263	-28.0
Critical Temperature (degrees F)	20.6	306	-116	269.6
Specific Gravity at Boiling Point	0.59	0.60	0.42	0.62

There are two basic types of liquified gas carriers. Liquified petroleum gas (LPG) tankers transport the heavy gases such as propane and butane in a semi-refrigerated, semi-pressurized containment system. Liquified natural gas (LNG) carriers transport natural gas, consisting primarily of methane, the lightest of the hydrocarbon gases. Because of its low critical temperature - the highest temperature at which the gas can be liquified by pressurization - cryogenic temperatures are required to liquify natural gas. This requirement presents a much greater challenge to ship design and construction than those of LPG carriers. Both LNG and LPG carriers have service speeds in the 16- to 19-knot range.

A double hull in some form is universally employed. Tanks are generally individual structures supported by the hull, and their shape and design depend on the working pressure and temperature. Three basic types are in general use:

- Free standing or self supporting tanks with sufficient strength to withstand cargo stresses. Tanks may be spherical, prismatic, or cylindrical in shape and fitted with a centerline wash-plate to reduce free-surface effect. Spherical and prismatic tank outlines are shown in Figure B-20.

- Membrane tanks fabricated from a thin stainless steel shell, or *membrane*, which is supported by load-bearing insulating material supported by the ships structure. In some of these tanks the membrane is double-skinned and the intervening space is filled with insulation.

- Semi-membrane tank, consisting of a strong, lightly stiffened outer skin, that cannot support its own weight. Rounded parts are left unsupported, so that they can flex to allow for expansion and contraction of the tank. They are similar in construction to the membrane tank but supported only at the base and sides.

The salvor called to assist an liquefied gas carrier should seek specialist advice regarding the nature of the gas being handled and, if necessary, the methods by which the cargo will be transferred. Cargo transfer must not be undertaken without due consideration of all the contingencies which can reasonably be foreseen. In the case of stranded or otherwise damaged refrigerated carriers, immediate and high priority should be given to providing power to the liquefaction plant to prevent uncontrolled boiloff. Unconfined LPG and LNG present severe fire, toxic, and cryogenic hazards. There have been a number of casualties to LPG vessels requiring salvage assistance, some are described in *Safe Havens for Disabled Gas Carriers* published by the Society of International Gas Tanker and Terminal Operators (SIGTTO) in November 1982.

B-6.12.1 Liquified Petroleum Gas (LPG) Tankers. *Fully pressurized LPG carriers* were first designed in the late 1940s, and are still the most common type of liquefied gas carrier. Cargo is carried at ambient temperature in uninsulated spherical or cylindrical pressure vessels. The pressure vessels are supported by cradles and are independent of the hull structure. Working pressures of about 285 psia allow propane to be carried at temperatures of up to 113 degrees Fahrenheit. Cargo capacity ranges from a few hundred cubic meters to about 5,000 cubic meters (about 18,000 cubic feet).

Refrigerated, semi-pressurized LPG tankers carry cargo in pressure vessels independent of hull structure. Cargo pressures are limited to 60 to 105 psig by permitting the cargo to boil and reliquefying the boil-off vapor. The tanks are insulated to minimize heat transfer from the surrounding environment. The first ships of this type, built in the early 1960s were limited to relatively high minimum cargo temperatures consistent with the designed cargo pressure range. New ships are built with tank materials and reliquefying plants capable of fully refrigerated carriage of LPG and the chemical liquefied gases at temperatures down to -58 degrees Fahrenheit. Some ships extend this capability to the fully refrigerated carriage of ethylene at -155 degrees. The lower design pressure allows larger tanks than for fully pressurized carriage; modern semi-pressurized ships may range up to 30,000 cubic meters (over 1,000,000 cubic feet) capacity.

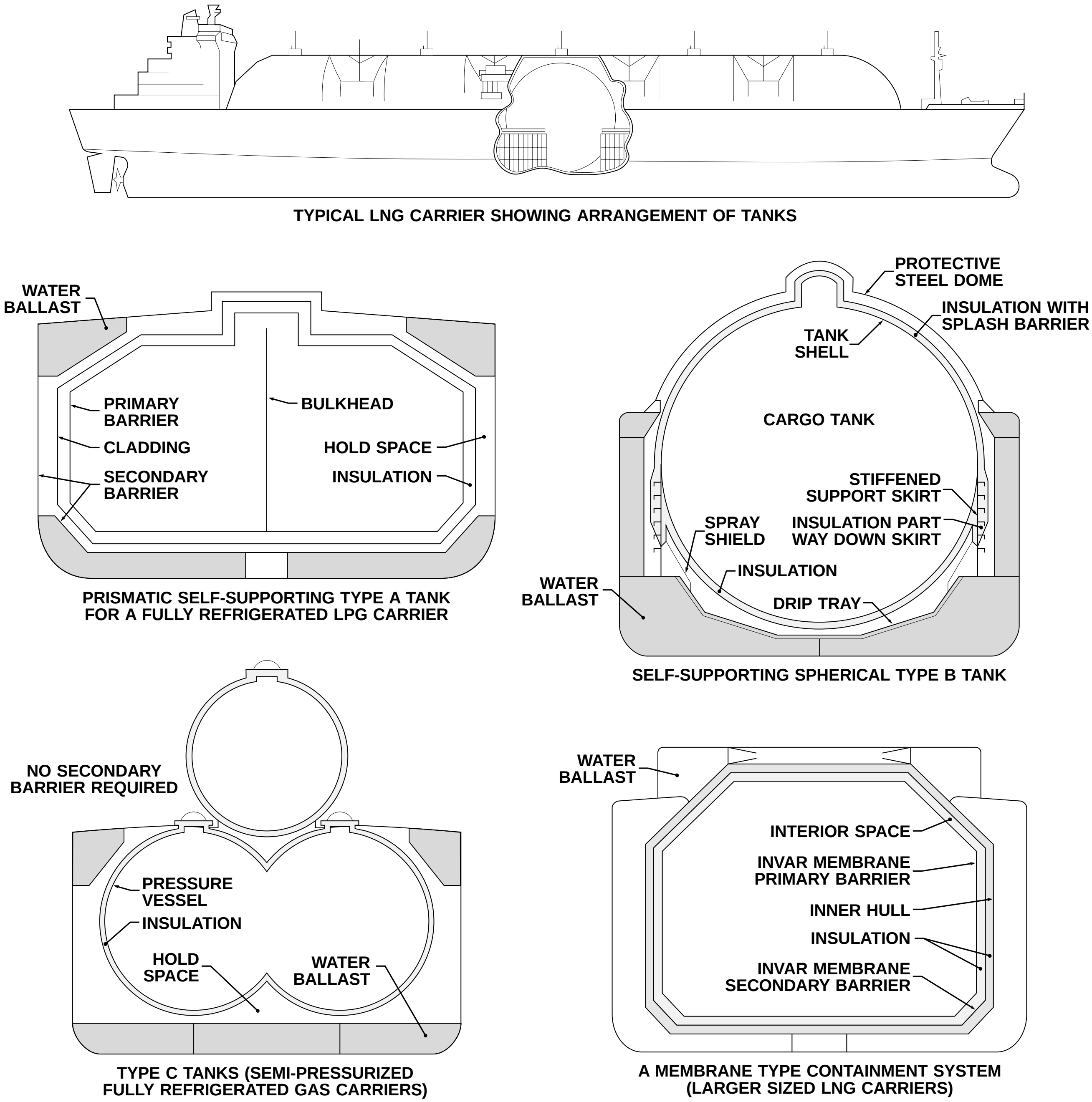


Figure B-20. Liquefied Gas Carriers.

Fully refrigerated LPG tankers carry LPG and the chemical liquefied gases under fully refrigerated conditions at near atmospheric pressure. The cargo tanks are generally self supporting, independent of the ship's structure, and prismatic to utilize hull space more efficiently. The tanks are often capable of working pressures of up to 11 psig, but normally operate at 3 to 5 psig. Tank materials, insulation, and liquefaction plant are designed for working temperatures down to -67 degrees Fahrenheit. Some ships are designed to carry ammonia or vinyl chloride monomer as well as the full range of liquefied petroleum gases. Capacities range from 5000 cubic meters to about 100,000 cubic meters (over 3.5 million cubic feet), or 65,000 tons deadweight.

B-6.12.2 Liquified Natural Gas (LNG) Carrier. LNG, principally methane, is invariably carried fully refrigerated at about -260 degrees Fahrenheit and near-atmospheric pressure. The heavily insulated cargo tanks may be either self-supporting or membrane type tanks. Self-supporting spherical or prismatic tanks are fabricated of aluminum or nickel steel. Typical tank sections are shown in Figure B-20.

Cargo is pumped aboard LNG carriers at its boiling temperature from a special loading facility. In this condition, volume is about 1/600 that of the gas at normal temperatures, and the stowage factor is about 85 cubic feet per long ton. Gas is discharged from the vessel by high- capacity submerged electric stainless steel pumps. In addition, three steam turbine-driven booster pumps are commonly located on deck. A common feature of LNG ships is the provision for capturing boiled-off LNG, which would otherwise be lost, and burning it as propulsion fuel. The gas can be burned directly as boiler fuel or mixed with fuel oil. Steam turbine propulsion is typically employed, although newer designs employ diesel plants. Many LNG ships feature bow thrusters, and most are fitted with dry powder fire protection and deck water spraying systems for the cargo tanks, plus a nitrogen inerting system for void tanks and spaces. Tables B-29 and B-31 list typical characteristics of LNG Ships.

Table B-29. Characteristics of Typical LNG Ships.

Dimensions (ft-in)	
Length overall	659-6
Length between perpendiculars	617-8
Beam	81-7
Depth	54-0
Design Draft	24-8
Speed and Power	
Design sea speed, knots	17
Shaft horsepower	15,000
Total Deadweight (long tons)	13,400
Capacity, ft^3	900,500

B-6.13 Chemical Carriers. Chemical carriers are designed to carry highly corrosive, poisonous and volatile chemicals. While most are designed for a specific chemical, parcel chemical carriers are constructed to permit simultaneous carriage of a variety of substances which require complete segregation. Parcel chemical tankers are similar in size and general layout to petroleum product tankers, but with a greater degree of cargo segregation and tank cladding. They may have separate piping/pumping systems designated to handle especially hazardous cargoes, or to segregate incompatible parcels. Because of the complex nature of the cargoes, options to shift of lighter cargo may be severely limited. Specialized lighters, pumps, and discharge lines may be required. As with petroleum products, the salvor must take care to balance the cargo's salvage with the safety of salvors and the local population, and the potential for environmental pollution.

The International Maritime Organization (IMO) groups chemical carriers into three types of ships—types I, II, and III. The requirements for each ship type are intended to minimize the effects of collision or grounding. The most hazardous chemicals are allocated to type I vessels, which require a double bottom for cargo tanks, which can not be closer than B/5 from the ship's sides measured at the load water line.

Type II chemical carriers are similarly designed as far as the double bottom is concerned, but cargoes can be carried to 29.92 inches from the ship's side, with side cofferdams absorbing the force of minor side damage.

Table B-30. Artubar Integrated Tug-Barge.

Dimensions (ft)	Tug	Barge
Length overall	150.0 ft	568.0 ft
Length between perpendiculars	134.5 ft	
Beam, overall	40.0 ft	85.0 ft
Depth, molded	24.5 ft	85.0 ft
Draft, design		12.0 ft
Draft, scantling	23.6 ft	
Deadweight and Displacement		
Deadweight, excluding ballast	250 tons	
Cargo deadweight and water ballast		6,450
Displacement at scantling draft	1,450 tons	12,130

Type III carriers are ordinary tankers, insofar as tank arrangement is concerned. Only a small number of chemicals are designated for such carriage. The IMO code also includes recommendations regarding the location of accommodations, ventilation of pump rooms, pumping arrangements, tank venting, tank gauging, etc, all with the intention of minimizing health hazards to the crew and the environment.

B-6.14 Barges. Barges are a common type of hull encountered in salvage work, and both as casualties and as important assets as lighters, pulling or lifting platforms, support units, etc. Various configurations are used by commercial and military interests. Large barges may have installed cargo handling or ballasting equipment, including pumps and piping for loading, shifting, or ballasting equipment. Ballast systems may be used for correcting trim, list, and stability problems imposed by cargo loading or casualty damage. There are many different types of barges, for the same reason that there are many types of merchant ships:

- Hopper barges for the transport of bulk cargo, which may be fitted with weathertight or watertight hatch covers. Bottom dump hopper barges are fitted with bottom opening doors for dumping rip-rap, dredge spoil, garbage, and the like, or for dumping coal and stone cargoes alongside piers where it is picked up by shore operated grabs or conveyers.

- Deck barges, which are essentially flat-topped pontoons designed for the transportation of vehicles or other heavy equipment, general cargoes, or for use as floating work platforms. Some are fitted with coamings for the transport of nonperishable cargo like scrap metal. Some deck barges are fitted with a light, shed-like structure to protect cargo or enclose work spaces.

- Dry cargo barges with holds and hatch covers like general cargo ships.

- Tank barges for carrying petroleum or other liquids. Tank barges may be quite specialized with regard to tank design and cargo handling systems. A significant amount of hazardous cargo, including liquefied and pressurized gases, is moved by barge on inland and coastal waterways. Some barges, especially those designed for the carriage of petroleum products, may have double bottom ballast tanks.

- Multi-deck RO/RO barges for the transport of vehicles and containers.

- Float-on/float-off barges for carrying smaller vessels, LASH lighters, or inland waterways craft on coastal or ocean voyages.

- Barges that combine some of the above features.

Despite specialization, all barges share certain features. Cargo distribution within the hull is not constrained by the requirements of propelling machinery or accommodations. Because tow speeds are quite low, barges have very full lines. Ocean barges may be 300 feet or more in length. Spoon, ship-shape, or flat rake bows may be fitted, while the stern is normally a flat transom with some cut up in the afterbody. Parallel midbody extends for as much as 80 percent of the length. Because of the low towing speeds, slamming and other ship motion induced forces are less than in a self propelled ship of the same size. Scantlings are therefore somewhat lighter than for a similarly sized ship.

In general, barges for inland and harbor use are not as rugged as those designed for the open sea. The tug and barge systems developed on the rivers of the Mississippi basin and in wide use on the Gulf Intracoastal and Atlantic Intracoastal waterways, use standard square barges lashed tightly together and connected to the tug at the bow. Considerable attempts have been made to standardize barge size on the river systems to facilitate making up tows. A common size for lower river barges is 175 feet by 35 feet by 11 feet. Barges intended for use together in a regular service are sometimes constructed as units of an *integrated tow*, that is, there are lead barges with forward rake, a number of square ended barges for the main part of the tow, and shorter after end barges.

Tugs engaged in pushing barges on U.S. inland waterways are almost universally referred to a *towboats* rather than tugs. U.S. inland towboats have nearly rectangular waterplanes with low freeboard. The bows are fitted with *push knees*, flat steel frames, faced with timber or heavy rubber pads, which provide a flush mating surface between the tug and barge. Cables used to secure the towboat to the barge are known as *facewires*, and are normally made up on winches located amidships or further aft on the towboat. Double push knees are preferable to a single knee as there is less strain on the facewires. Push knees are to a towboat what towing bitts are to an oceangoing tug; thrust developed by the tug is focused at this point. Barges are arranged in longitudinal rows called *strings*; the string directly ahead of the towboat is the *push string*; those outboard are *drag strings*. River width and turns limit the size of both tow and towboat. Tows on the rivers above Pittsburgh seldom consist of more than 6 barges, handled by 60- to 90-foot towboats of 800 to 1,500 horsepower. On the Ohio and upper Mississippi, tows may consist of 12 to 15 barges handled by 160-foot towboats of 3,000 to 4,000 horsepower. On the lower Mississippi, tows of 40 to 60 barges are handled by towboats of 8,000 to 10,000 horsepower.

Integrated tug/barge units are used widely in the U.S Gulf and east coast offshore trade. The stern is notched to accept a special tug which can be rigidly connected to the barge, forming a single vessel. The barge is built in the molded form of a normal ships hull. In the most efficient systems, the tug is attached by trunion mountings protruding from the bow into sockets fitted along the inside of the barges recesses. Directional stability and control underway is far superior to that of a towed barge. No particular changes in the size or shape of the tug are required except for a higher pilot house, needed for improved visibility. Characteristics of an *Artubar* tug-barge are given in Table B-30.

B-6.15 Vessel Characteristics Tables. The following tables provide characteristics for typical commercial vessels. As hull design is constantly evolving, the tables are arranged by year group; each table lists typical vessels in service at the indicated time.

Table B-31. Form Characteristics of Typical Commercial Vessels, circa 1988.

	General Cargo	Cargo-Passenger	Container Ship	Container Ship	RO/RO	Barge Carrier (Stretch LASH)	Bulk Carrier (OBO)	Great Lakes Ore Carrier
Dimensions, ft-in:								
LOA	563-8	346-8	860	610	684	893-4	897-6	1000
LBP	563-8	508-6	810	581	640	797-4	855	988-6
Length for coefficients, *L*	520	505-5	810	580	640	813-4	855	988-6
D (molded, to strength *dk*)	44-6	48.3	66	54-6	69-6	60	62-6	49
B (molded)	76	79	105-9	78	102	100	105-9	104-7
T (molded, for coeffs)	27	27	35	27	32	28	45-10	25-9
Δ (molded, in seawater) lton	18,970	17965	49583	22,380	34,430	38,400	100,500	71,440
Coefficients and Proportions:								
Block, C_B	0.612	0.583	0.579	0.630	0.568	0.582	0.836	0.924
Midship, C_M	0.981	0.967	0.965	0.975	0.972	0.922	0.996	0.999
Prismatic, C_P	0.624	0.603	0.600	0.646	0.584	0.631	0.839	0.924
Waterplane, C_W	0.724	0.725	0.748	0.740	0.671	0.765	0.898	0.975
Vertical prismatic, C_{VP}	0.845	0.807	0.774	0.851	0.846	0.762	0.931	0.948
LCB from midship, % *L*	1.5A	Amids	1.1A	1.2A	2.4A	1.6A	2.5F	0.5F
Bulb area, % midship area	4.0	2.5	8.3	4.0	9.7	5.6	10.7	0
L/B	6.84	6.40	7.94	7.44	6.27	8.13	8.09	9.45
B/T	2.81	2.93	2.91	2.89	3.19	3.57	2.31	4.06
Shaft horsepower, normal	17,500	18,000	43,200	19,250	37,000	32,060	24,000	14,000
Sea speed, knots	20	20	25	20	23	22	16.5	13.9
Number of propellers, rudders	1,1	1,1	1,1	1,1	1,1	1,1	1,1	2,2
	VLCC[1]	Products Tanker	LNG Tanker	Off-Shore Supply Vessel	Double-ended Ferry[2]	Fishing Trawler	Arctic Ice-Breaker	Passenger Liner
Dimensions, ft-in:								
LOA	1100	661	936	185-3	310	84-2	399	990
LBP	1060	630	897	174-6	300-6	75-7	351	905
Length for coefficients, *L*	1060	630	897	174-6	300-6	77-11	352	941-6
D (molded, to strength dk)	86	45-3	82	14	20-8	10-11	43-3	74-3
B (molded)	178	90	143-6	40	65	22	78	101-6
T (molded, for coeffs)	66-11	34-1	36	11	12-6	8-4	28	31-8
Δ (molded, in seawater) lton	303,877	42,772	95,681	1449	2717	219	10,730	45990
Coefficients and Proportions:								
Block, C_B	0.842	0.772	0.722	0.660	0.392	0.538	0.488	0.532
Midship, C_M	0.996	0.986	0.995	0.906	0.732	0.833	0.853	0.953
Prismatic, C_P	0.845	0.784	0.726	0.729	0.534	0.646	0.572	0.558
Waterplane, C_W	0.916	0.854	0.797	0.892	0.702	0.872	0.740	0.687
Vertical prismatic, C_{VP}	0.919	0.904	0.906	0.740	0.558	0.617	0.660	0.774
LCB from midship, % *L*	2.7F	1.9F	Amids	0.3A	Amids	1.7A	1.3F	Amids
Bulb area, % midship area	0	0	9.7	0	0	0	0	2.0
L/B	5.96	7.00	6.25	4.35	4.62	3.54	4.51	9.28
B/T	2.66	2.64	3.99	3.33	5.20	2.65	2.79	3.21
Shaft horsepower, normal	35,000	15,000	34,400	3,740	7,000	500	18,000	158,000
Sea speed, knots	15.2	16.5	20.4	12	16.1	10.7	18	33
Number of propellers, rudders	1,1	1,1	1,1	2,2	2,0	1,1	3,1	4,1

1 – Cylinder bow.
2 – Vertical axis propellers and a fixed skeg at each end.
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Table B-32. Form Characteristics of Typical Commercial Vessels, circa 1980.

	Large General Cargo	Small General Cargo	Container Ship	Product Tanker	VLCC	Bulk Carrier
Dimensions, ft-in:						
LOA	605-0	295-0	719	688-6	1187-6[4]	611-10
LBP	582-6	274-0	677	660-0	1143-0	584-0
B (molded)	82-0	45-0	95	90-0	228-0	93-2
D (molded, to main deck)	46-0	22-0	54	47-0	95-0	50-2
T (full load)	35-0	14-10	34	35-0	74-0	32-0
Block coefficient, C_B	0.670	0.700	0.619	0.796	0.799	---
L/B	7.10	6.09	7.13	7.33	5.14	6.27
B/T	2.34	3.04	2.79	2.57	3.08	2.91
Weights, lton:						
Lightship	9,787	1588	14,574	7569	60,140	---
Passengers, crew, stores	60	---	350	50	50	---
Fuel	3596	286	6943	3624	17,857	1943
Fresh water	608	11.5	589[1]	275	315	226
Refrigerated cargo	218		---	---	---	---
Liquid cargo	2377		---	39,934	372,000	---
General cargo	15,349		---	---	---	---
Total deadweight	22,208	2062	24,126	40,760	390,770	32,100
Full load displacement	31,995	3650	38,700	47,281	450,910	---
Capacities:						
General cargo, bale, ft^3	1,082,207	128,237	1,300,500	---	---	1,603,890
Refrigerated cargo, net, ft^3	21,839	23,938	---	---	---	---
Total containers, TEU	409	74	1334[2]	---	---	---
In hold	325	---	1046	---	---	---
On deck	84	---	288	---	---	---
Holds	7	3	4	18	36	9
Passengers	12	---	2	3	11	8
Crew	41	11	37	29	27	26
Shaft horsepower	24,000	2800	32,000	15,000	45,000	---
Sea speed, kts	20.8	13.75	22.8	16	15.9	16.9
Number of propellers	1	1	1	1	1	1
Propeller diameter, ft	22	---	22.5	22	31.5	---
Machinery	steam turbine	diesel	steam turbine	steam turbine	steam turbine	diesel
House, machinery location	2/3 aft	aft	aft[3]	aft	aft	aft

Notes:

1 – Additional 1,790 tons water in anti-roll tank.
2 – Actual capacity 178 forty-foot and 559 thirty-five-foot containers.
3 – Navigating bridge forward of container deck.
4 – 1,171 foot LWL.

Table B-33. Form Characteristics of Typical Vessels, circa 1965.

	Ocean Cargo	Ocean Cargo	Coastwise Passenger and Cargo Liner	Oil tanker	Great Lakes Bulk Freighter	Trans-Atlantic Passenger liner	Intermediate Passenger liner	Ocean power yacht	Harbor Tug
Dimensions, ft-in:									
LOA	442-2	410-11	429-2	501-8	604	814-8	654-3	247-6	105-9
LWL	425	390	412	497-6		800-11	630-0	206	100-4
LBP	425		412	485-6	587-11		615-0		100-4
length for coefficients, L	425	385	412	485-6	580	800-11	630	206	100-4
B (molded)	57	55	59-6	68	60	95-9	81	34	24
D (molded, to upperdeck	42	30-6	35	37	32	62-10	52	19	12-9
D (molded, to strength deck)	42	38-6	43-6	37	32	79-11	70	19	12-9
T_m (molded)	28	24-5	24-6	29-8	20	30-6	32	12-6	10-9
Δ (molded, seawater), lton	15,072	10,540	11,040	21,200	17350	39998	31313	1413	433
Speed, kts	12	13	15.5	13.8	10.4	26.25	20	14.6	8.8
Shaft horsepower	3200	3150	6000	3600	2150	100,000	26500	2415	600
Coefficients:									
Block, C_B	0.775	0.714	0.643	0.757	0.874	0.597	0.669	0.565	0.585
Midship, C_M	0.992	0.986	0.967	0.978	0.990	0.956	0.988	0.938	0.892
Prismatic, C_P	0.782	0.724	0.664	0.774	0.883	0.625	0.678	0.602	0.655
Waterplane, C_{WP}	0.848	0.804	0.768	0.845	0.918	0.725	0.773	0.724	0.800
Vertical prismatic, C_{VP}	0.946	0.889	0.838	0.896	0.957	0.823	0.866	0.782	0.732
Ratios:									
L/B	7.46	7.00	6.92	7.15	9.67	8.38	7.78	6.06	4.18
L/T	15.18	15.78	16.82	16.36	29	26.25	19.69	16.47	9.33
B/T	2.04	2.25	2.43	2.29	3	3.14	2.53	2.72	2.23
speed-length, $V/\sqrt{L}$	0.582	0.663	0.764	0.625	0.433	0.928	0.797	1.013	0.875

Table B-34A. Characteristics of Typical Merchant Ships, cira 1965.

	Mariner, with Added Features (1962)	General Cargo (Fig B-9)	Passenger Cargo	Container Ship (Fig B-12)	Barge Carrier (LASH) (Fig B-14)	Barge Carrier (SEABEE) (Fig B-14)	Tanker	Ore Carrier
Dimensions, ft-in								
LOA	565-0	573-11	546-8	752-0	820-0	873-9	809-10	765-0
LBP	528-0	544-6	508-6	705-9	724-0	719-11	763-0	732-0
Beam (*B*), ft-in	76-0	82-0	79-0	100-6	100-0	105-10	125-0	102-0
D_S (to strength deck)	44-6	45-6	48-1	57-0	60-0	74-9	54-6	56-5
T_{max} (maximum molded)	31-7	30-6	29-1	29-0	28-0	32-9	41-2	38-3
Δ, seawater, lton	22,630	21,235	19,799	33,924	32,800	44,500	90,400	66,200
Total Deadweight, lton	13,735	12,932	9,234	19,524	18,760	26,600	75,600	51,050
Deadweight/displacement	0.607	0.609	0.466	0.575	0.572	0.598	0.836	0.771
Form:								
Length for coefficients, L	520'-0"	540'-0"	508-6	722-0	740-0	740-0	763-0	730-0
T_D (design)	27'-0"	28'-5"	27-0	29-0	28-0	31-0	39-10	38-0
Δ (molded, at *T*), lton	18,674	19,340	18,009	33,500	32,600	40,800	87,130	65,300
Coefficients								
Block	0.6125	0.539	0.5811	0.558	0.551	0.589	0.802	0.808
Prismatic	0.6246	0.559	0.6014	0.560	0.595	0.608	0.804	0.812
Maximum section	0.9807	0.963	0.9663	0.997	0.928	0.968	0.997	0.995
Waterplane	0.7236	0.685	0.7188	0.700	0.767	0.870	0.874	0.883
Ratios:								
LBP/D	11.87	11.97	10.58	12.38	12.07	9.63	14.00	12.97
T/D_S	0.710	0.670	0.605	0.509	0.467	0.438	0.755	0.677
B/T_D	2.81	2.89	2.93	3.46	3.57	3.41	3.134	2.68
LBP/B	6.95	6.64	6.44	7.02	7.24	6.80	6.104	7.18
Wetted surface, total, sq ft	50,006	51,750	48,650	...	80,748	98,700	131,850	...
KM, ft	31.09	34.60	33.8	40.15	48.82	59.35	52.67	42.20
MT1 in, ft-tons	1776	1860	1745	4840	5794	8605	10,222	7780
TPI	68.09	72.2	68.74	120.30	135.2	162.2	200.2	157.2
Stability:								
GM, light ship, ft	2.6	1.8	1.4	16.8	22.1	20.0	127.8	54.9
GM, loaded, ft	5.0	3.6 corr	3.2 corr	5.0	8.0	7.6	21.0 corr	15.7
Capacities:								
Passengers	12	12	119	0	4	4	0	0
Crew	58	45	121	40	39	40	28	47
Dry cargo, bale, ft^3	555,499	782,400	625,600	1200 TEU	1,208,235	1,421,000	641,000 bbl	2,150,000
Refr cargo, bale,	87,612	50,000	19,355					
Stores, net, ft^3	12,159	11,991	11,149					
Machinery *:								
SHP, maximum	19,250	24,000	19,800	60,000	32,000	36,000	19,000	22,000
Boilers	2	1	2	2	2	2	1	2
Screws	1	1	1	2	1	1	1	1
Speed, kts (trial, at 80% SHP at T_{max})	20	23	20	27	22.5	20.2	16.8	16.5

* Steam turbine for all ships listed

Table B-34B. Weights and Centers for Typical Merchant Ships, circa 1965.

	Mariner with Added Features (1962)			General Cargo			Passenger Cargo			Container Ship		
Weight groups:	TONS	VCG	LCG	TONS	VCG	LCG	TONS	VCG	LCG	TONS	VCG	LCG
Net steel	5,115	27.6	274.1	5,011	32.2	291.0	5,482	32.2	267.8	10,282	32.6	364.2
Outfit	2,586	47.0	281.3	2,230	48.1	295.6	3,959	41.0	261.7	2,525	47.7	338.0
Machinery	1,039	22.1	340.1	867	26.0	398.4	982	23.4	320.7	1,911	25.7	524.0
Margin	155	(+1.1)	(+0.7)	195	(+1.0)	0	142	(+0.2)	(+0.2)	432	(+1.0)	0
Light ship, Total	8,895	33.8	284.8	8,303	36.9	303.7	10,565	35.0	270.7	14,718	35.3	380.4
Misc. deadweight	39	17.9	328.9	252	17.2	45.7	145	41.0	262.7	...	...	...
Passengers, crew, and stores	80	45.1	311.8	40	53.8	332.5	50	62.0	285.2	400	36.2	324.4
Swimming pool	0	---	---	0	---	---	68	53.8	366.8	0	0	0
Fuel oil	2,963	6.0	243.4	2,350	8.8	827.3	1,100	3.4	237.6	6,000	10.0	377.2
Fresh water	158	12.8	314.9	170	39.8	304.5	176	17.6	199.1	...	...	...
General cargo	7,009	30.4	224.7	8,740	31.4	259.4	5,928	30.8	252.7	12,806	46.3	373.8
Refrigerated cargo	876	37.3	335.0	480	39.3	398.5	276	53.0	65.1	...	...	...
Deep tanks, liquid cargo	2,610	13.5	313.3	1,000	18.2	241.5	1,491	8.9	299.5	...	...	...
Deadweight, total	13,735	22.1	254.3	12,932	26.7	266.9	9,234	24.9	252.5	19,206	34.8	373.8
Full load, displacement, total	22,630	26.7	266.4	21,235	30.7	281.3	19,799	30.3	262.2	33.924	35.0	376.7
Selected Unit Weights:												
Propulsion Machinery												
Boilers, turbines and gears	519.3			463.5			456.5			1091.5		
Shafting and bearings	167.1			120.5			168.7			331.3		
Propeller(s)	25.4			26.9			27.8			38.2		
Liquids in machinery	88.5			91.8			92.6			101.4		
Deck machinery	190.4			211.0			139.4			38.3		
Outfit:												
Hatch covers	351.5			481.4			114.4			617.7		
Mooring fittings	68.4			33.5			49.5			68.6		
Masts, booms, kingposts,	107			255.1			39.5			70.8		
Rigging and blocks	80.4			41.8			5.6			1.0		
Boats and boat handling	19.7			18.4			31.7			13.9		
Anchor and chain	78.1			68.9			83.4			151.5		
Weight Groups:	Barge Carrier (LASH)			Barge Carrier (SEABEE)			Tanker			Ore Carrier		
Net steel	9,588	33.1	389.4	12,983	41.9	424.6	11,519	29.9	388.8	12,137	30.5	378.0
Outfit	2,937	59.0	339.0	2,979	57.9	443.2	1,844	46.8	456.4	1,600	55.0	428.3
Machinery	1,105	21.8	536.7	1,421	19.9	519.5	831	30.9	661.4	980	33.0	641.6
Margin	410	(+1.0)	0	517	(+1.0)	0	606	(+1.0)	0	440	(+0.1)	0
Light ship, Total	14,040	38.8	390.4	17,900	43.8	435.5	14,800	33.2	413.6	15,157	34.1	401.0
Misc. deadweight	450	27.3	166.7	600	10.9	426.3	...	...	...	...	...	...
Passengers, crew, and stores	500	77.0	102.0	70	72.0	211.0	...	...	...	100	65.0	595.0
Fuel oil	3,500	27.8	390.4	2,683	15.4	294.6	2,500	...	...	4,157	46.4	443.2
Fresh water	555	37.3	538.0	630	15.1	439.2	...	...	...	470	24.0	664.3
General cargo	14,205	46.5	416.7	22,617	61.6	416.5	...	...	...	46,316	22.1	329.7
Refrigerator cargo	...	...	...	...	...	...	...	...	...	...	...	...
Deep tanks, liquid cargo	...	...	...	...	...	...	...	...	...	...	...	...
Deadweight, total	18,760	42.3	408.7	26,600	54.7	404.4	75,600	...	...	51,043	24.2	342.5
Full load, total	32,800	40.8	400.8	44,500	50.3	416.9	90,400	...	...	66,200	26.5	355.9
Selected Unit Weights:												
Propulsion Machinery												
Boilers, turbines and gears	516.6			630.2			448.8			489.9		
Shafting and bearings	212.0			293.7			64.8			121.1		
Propeller(s)	36.8			50.4			36.6			31.7		
Liquids in machinery	87.5			122.0			87.6			90.3		
Deck machinery	626.8			472.7								
Outfit:							134.2			74.0		
Hatch covers	565.8			6.9			---			433.3		
Mooring fittings	69.8			48.9			131.7			84.0		
Masts, booms, kingposts,	---			4.9			42.3			11.2		
Rigging and blocks	0.8			0.7			2.4			2.8		
Boats and boat handling	19.8			15.5			16.2			13.4		
Anchor and chain	116.4			123.4			133.6			161.7		

Weights in long tons, LCG abaft FP, VCG above molded base line in decimal feet

Table B-35A. Characteristics of Typical Merchant Ships, circa 1953.

	General Cargo (MARAD VC2)	General Cargo (*Mariner*)	Cargo and Passenger	Passenger (twin screw)	Tanker	Tanker	Tanker
Dimensions, ft-in:							
LOA	459-3	563-8	491-10	723-0	565-0	628-0	707-0
LBP	435-0	528-0	465-0	660-7	535-0	600-0	677-0
B	63-0	76-0	69-6	93-3	75-0	82-6	93-0
D_S (to strength deck)	40-6	44-6	42-6	73-7	40-6	42-6	48-6
D (to freeboard or bhd. deck)	31-6	35-6	33-6	45-5	40-6	42-6	48-6
T (maximum molded)	25-9[a]	29-9	26-6[a]	32-6[a]	31-9	31-10	36-7
Displacement, total, lton	13,859	21,093	16,175	35,440	25,510	34,640	49,660
Deadweight, total, lton	9,493	13,409	9,937	14,331	19,183	26,759	38,911
Displacement/deadweight	1.46	1.57	1.63	2.47	1.33	1.29	1.28
Form:							
Length for coefficients (*L*) ft-in	435-0	520-0	465-0	689-0	535-0	600-0	675-0
Displacement, molded, lton	13,771	20,958	16,072	34,960	25,385	34,481	49,405
Coefficients:							
Block (C_B)	0.683	0.624	0.658	0.586	0.698	0.764	0.755
Prismatic (C_P)	0.697	0.635	0.670	0.600	0.702	0.770	0.765
Maximum section (C_M)	0.980	0.983	0.980	0.977	0.994	0.993	0.987
Waterplane (C_{WP})	0.762	0.745	0.763	0.715	0.792	0.828	0.836
Wetted surface, total, sq ft	38,760	53,210	43,270	81,930	59,050	73,300	92,120
KM, ft	25.28	31.40	28.71	38.24	30.81	33.08	38.20
MT1in ft-lton	1171	1927	1472	3923	2351	3627	5066
TPI, lton	49.7	70.1	58.6	109.4	75.9	97.8	125.0
Proportions:							
LBP/D_S	10.74	11.87	10.94	8.98	13.21	14.12	13.96
LBP/D	13.81	14.87	13.88	14.53	0.784	0.749	0.754
T/D	0.817	0.838	0.791	0.715	2.36	2.59	2.54
B/T	2.45	2.55	2.62	2.87	21.50	22.50	25.30
LBP/B	6.90	6.95	6.69	7.08	7.13	7.27	7.28
Stability, ft:							
GM, light ship,	11.92	6.78	7.76	1.90	20.8	39.9	45.1
Free surface corr. (loaded)	-3.11	-0.88	-1.42	-0.47	-1.19	-1.39	-1.24
GM, loaded	1.85	4.62	2.53	5.60	6.63	9.25	10.31
Capacities:							
Passengers	2	2	96	1202	2	4	4
Crew	48	56	123	643	47	58	54
Fresh water, lton	322	257	917	4720	147	196	179
Fuel oil, lton	1386	3808	2769	4938	1969	2679	3830
Cargo:							
Dry, bale, ft^3	457,900	736,723	436,000	259,980	45,150	44,590	62,430
Refrigerated, net, ft^3	32,290	30,254	43,200	33,510	---	---	---
Liquid, bbl	20,630	---	---	---	153,419	225,023	329,578
Stores, etc, net, ft^3:					---	---1	---
Dry	1290	1256	6200	30,465			
Refrigerated	2268	4092	8540	34,350	1920	3300	3610
Mail	---	---	4920	30,137	---	---	---
Baggage	---	---	3825	19,650	---	---	---
Machinery[b]:							
SHP, normal							
SHP, maximum	6000	17500	8500	34000	13,650	12,500	20,000
Boilers	6600	19250	9350	37400	15,000	13,750	22,000
Position	2	2	2	2	2	2	2
Speed, kts	abaft midships	midships	midships	midships	aft	aft	aft
(trial at 80% SHP at T_m)	15.5	20	17	22	18.5	16.5	18

a. to subdivision loadline
b. steam turbine in all cases, single screw unless otherwise noted

Table B-35B. Weight Summaries for Typical Merchant Ships, circa 1953.

	General Cargo (MARAD VC2)			General Cargo (*Mariner*)			Cargo and Passenger			Passenger (twin screw)		
Weight Groups:	Tons	LCG*	VCG*	Tons	LCG*	VCG*	Tons	LCG*	VCG*	Tons	LCG*	VCG*
Net steel	2857	219.2	23.71	4695	270.6	29.80	3807	234.8	27.57	11380	357.0	39.80
Wood and outfit	721	215.4	31.83	1298	264.7	44.90	1168	227.8	38.90	5260	353.0	54.90
Hull engineering (wet)	210	230.1	36.33	682	280.6	36.80	500	241.2	40.60	1950	354.5	45.80
Machinery (wet)	578	275.2	19.33	1009	315.1	20.60	763	276.5	15.30	2519	373.5	21.50
Light ship, total	**4366**	**226.5**	**25.08**	**7684**	**276.3**	**31.76**	**6238**	**239.1**	**29.24**	**21109**	**357.7**	**41.93**
Crew and stores	28	261.2	37.00	63	293.3	44.2	---	---	---	---	---	---
Passengers, crew, and effects	---	---	---	---	---	---	28	247.0	44.50	150	411.5	51.65
Mail, baggage, and stores	---	---	---	---	---	---	100	200.7	30.56	480	504.5	21.12
Swimming pool	---	---	---	---	---	---	50	303.5	48.60	110	422.6	22.55
Fuel oil	1386	197.5	3.01	3808	270.0	7.5	1520	243.1	4.96	4456	301.3	13.33
Fresh water	322	255.3	4.75	257	299.0	22.9	916	199.6	9.91	4280	414.4	9.99
General cargo	4533	202.4	25.77	8978	257.1	28.6	6891	229.3	27.39	1625	166.8	23.50
Refrigerator cargo	328	194.3	30.51	303	358.2	26.6	432	205.4	13.95	375	209.8	26.11
Deep tanks, liquid cargo	2896	210.3	13.31	---	---	---	---	---	---	---	---	---
Deadweight, total	**9493**	**205.7**	**18.13**	**13409**	**264.0**	**22.52**	**9937**	**229.2**	**21.95**	**11476**	**332.5**	**14.85**
Full load, total	13859	212.3	20.32	21093	269.0	25.9	16175	232.1	24.76	32585*	348.8	32.46
Selected Unit Weights:												
Propulsion Machinery												
Main boilers	113			185			128			496		
Main turbines and gears	95			160			123			350		
Shafting and bearers	80			165			97			469		
Propeller(s)	14			29			22			42		
Pumps	25			32			47			75		
Machry rm gratings, ladders	29			42			36			89		
Liquids in machinery	46			95			94			192		
Winches, windlass, capstans	47			162			62			193		
Outfit:												
Mooring fittings, hawse pipes	33			51			37			79		
Hatch covers, manholes	93			399			50			73		
Booms and fittings	26			73			25			31		
Rudder and stock	19			26			23			47		
Rigging and blocks	25			53			24			23		
Boats and boat handling	7			16			20			184		
Anchor and chain	56			75			60			124		
	565 ft Tanker			628 ft Tanker			707 ft Tanker					
Net steel	4486	280.3	26.30	5899	301.4	26.73	8379	339.1	29.60			
Wood and outfit	540	291.1	47.50	595	320.2	49.12	620	343.6	55.50			
Hull engineering (wet)	477	310.8	28.20	576	351.9	29.57	730	410.8	33.80			
Machinery (wet)	824	451.3	23.80	811	520.6	24.30	1020	585.4	24.80			
Light ship, total	**6327**	**305.8**	**27.93**	**7881**	**329.1**	**28.38**	**10749**	**367.6**	**30.92**			
Cargo oil	18098	244.4	20.71	25329	276.8	20.94	37896	309.1	25.25			
Fuel oil	880	409.7	21.90	900	355.2	19.62	775	536.7	28.58			
Fresh water	140	432.8	42.45	475	541.1	27.58	165	602.4	50.41			
Crew and effects	65	452.3	37.84	55	379.5	47.33	75	450.0	53.00			
Deadweight, total	**19183**	**254.0**	**21.29**	**26759**	**284.3**	**21.06**	**38911**	**315.1**	**25.47**			
Full load, total	25510	266.7	22.99	34640	291.1	22.44	49660	325.9	26.65			
Selected Unit Weights:												
Propulsion Machinery												
Main boilers	175			154			186					
Main turbines and gears	109			112			155					
Shafting and bearers	69			53			87					
Propeller(s)	26			21			30					
Cargo pumps	19			15			23					
Other pumps	31			37			35					
Machry rm gratings, ladders	38			42			48					
Liquids in machinery	75			19			89					
Winches, windlass, capstans	53			52			75					
Outfit:												
Mooring fittings, hawse pipes	27			33			36					
Hatch covers, manholes	31			36			37					
Booms and fittings	9			10			11					
Rudder and stock	22			26			31					
Rigging and blocks	6			1			7					
Boats and boat handling	9			20			14					
Anchor and chain	76			92			107					

LCG from FP, VCG above molded baseline
* Typical maximum operating condition at 30-foot 4-inch molded draft